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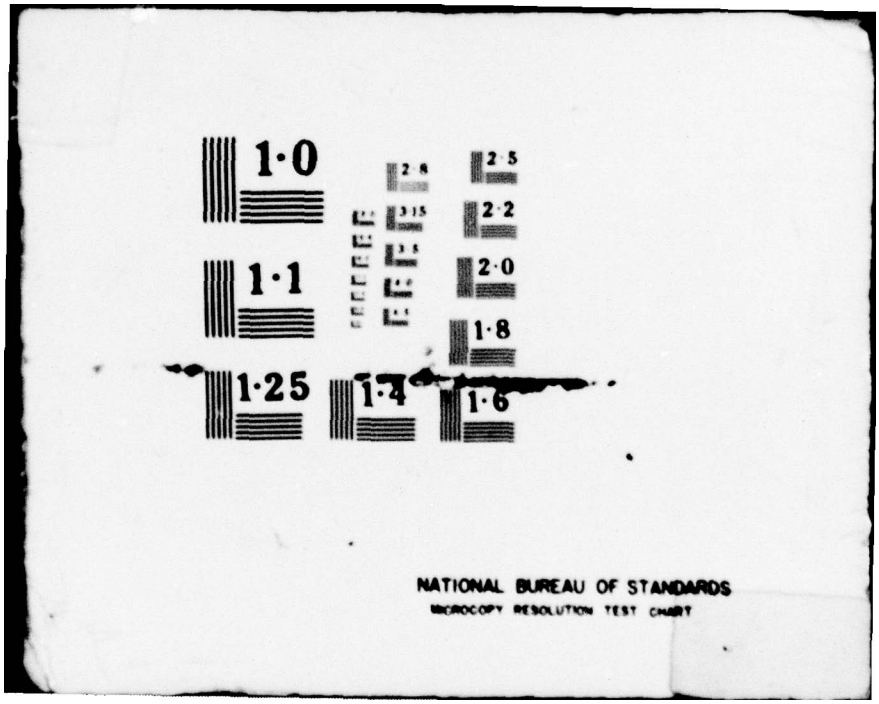
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Volume 33, Number 7

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31 July 1979

I. /Kaufman S. /Hewitson

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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scientific staffs of the United States Air Force's European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

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(cont'd p. A)

Topics in this issue include:

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LONDON

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HERBERT SOLOMON
Chief Scientist

P.F. GIBBER
Captain, USN
Commanding Officer

AVIATION

LA RENAISSANCE DU DIRIGEABLE—A SOLUTION IN SEARCH OF A PROBLEM

As a result of new environmental regulations, interest in ecology, the increased cost of fuel, and the natural romance of Lighter-Than-Air (LTA), AERALL (Association d'Etude et de Recherche sur les Aéronefs Allégés, Paris, France) is advocating the rebirth of the airship, or aerostat. The second symposium on the Economics and Technology of Modern Airships was conducted by AERALL at the Tour Olivier-de-Serres on the southern edge of Paris on 28 to 30 March. Although the 200 attendees were chiefly French, at least a dozen countries from Africa, North and South America and a large contingent from Japan were in attendance.

M. Jean-Claude Empereur of AERALL opened the forum and explained that the first meeting in 1973 was concerned with the feasibility of aerostats—economic studies, identification of technical problems, and commercial uses. He stated that the rebirth is concrete and beyond speculation, as could be seen in the worldwide interest in aerostats over the past few years. He stressed that the airship could be used economically to fill gaps in current transportation systems and that skepticism on the part of the technical people would be overcome by the support of public opinion.

M. Serge Antoine, Head of the R&D Mission of the French Ministry of the Environment, stressed the use of LTA as a nonpolluting method of low-speed and/or heavy-lift transportation and observation. He could see uses in the movement of lumber; large, nondivisible industrial machinery, and construction parts; and as a means of surveillance of road traffic, disposal of waste material, river pollution, and off-shore oil exploration. He said that studies have been done, the technical problem tackled, and it is time to get moving NOW—to stop singing the praises of the airship and to start marching.

M. Adelin Villevieille, Director of the R&D Department of the Etablissement d'Etudes et de Recherches Météorologiques, Paris (EERM) cited some additional uses as a poor man's satellite for certain meteorological data gathering and telecommunications use.

M. Jacques Bouttes, Director for Aerospace Applications, Office National d'Etudes et de Recherches Aérospatiales, Chatillon, France (ONERA) became more pragmatic and said that an industrial environment is needed. On paper the technical problems are <u>not</u> insurmountable, but a systems approach is required to compete with other modes of transportation and satisfy safety requirements. The airship was developed between WWI and WWII and was at that time at a high state of technology. Rigid LTA was dropped owing to vulnerability (inflated by H_2), while aircraft continued development. There is a need to relearn and reteach the mechanics, aerodynamics, and aerothermics (gas in large envelopes) of the airship. He said the rebirth could only be done by enormous companies with long-standing industrial tradition with interdisciplinary teams to exploit new techniques and technologies, since there would be no immediate return on investment—i.e., within 10 years.

The first project to be examined was the Helicostat AZ-100 by M. Roger Gau of Société Nationale Industrielle Aérospatiale, Paris (SNIAS). The helicostat is designed as a 4 metric-ton lifting device for timber transport from inaccessible mountainous areas in France; i.e., the Pyrenees and mountainous regions of southeast France. The AZ-100 is a hybrid, combining a nonrigid balloon of a 3000-m^3 volume and two cross-linked helicopter rotors. The cost per ton moved calculates to be less than for a helicopter. Aerodynamic feasibility and other studies have been completed, and SNIAS expect something concrete to materialize in the near future.

The DINOSAUR, a remote-controlled meteorological airship sponsored by EERM, was described by M. Marcel Zephoris. A 1/25 model was studied and tested; similarly, a 1/3-scale model has been built and flown. He emphasized the uses of the DINOSAUR for low-altitude atmospheric studies in cloud physics, rain formation, pollution and dust effects on the microphysics of cloud formation, and surveillance of air pollution. The results could lead to control of rain and to the development of computer models for air pollution. Slides and films of some of the flight tests of the 1/3 model were shown. The DINOSAUR would carry a payload of approximately 1100 kg at sea level and 250 kg at

3000 m. No decision has as yet been made on building a full-scale prototype.

M. Denoix of SODETEG, Le Plessis Robinson, France, spoke of the economics of heavy-lift aerostats. He considered 3 types. A mini-airship with a payload of 2 to 2.5 tons with a 1000 to 2000 km range could be cost effective at 3500 flight hours per year at a cost of $500 per flight hour. He calculated a world market of 500 vehicles in this range at about $2 million per copy. A larger vehicle with 10-25 tons payload would have a smaller market of about 200. He estimated that development would cost FF70 million (about FF4.1 to the dollar) and production aerostats would cost about FF30 million. The economics of heavy-lift vehicles becomes dramatically better as size increases. The 10-25-ton unit would cost FF4 per ton moved; a 100-t vehicle, FF1 per ton moved; and a 500 t, only FF0.3 per ton moved. At present the concept is in the artist-conception stage.

Representatives of the Brazilian government announced an RFP (request for proposal) in expressing interest in heavy cargo transport in the Western areas of Brazil where there is little existing infrastructure. The cargo would be heavy construction materials, timber, and items like transformers and generators for hydroelectric or nuclear power projects. The vehicle would probably be in the 300-ton payload category. There was approximately $300,000 for a 15-month study to be started in mid-1979. Similar interests were expressed by Alberta Transportation of Canada and the Japanese Ministry of Internal Trade and Industry. The Japanese studies show that small LTA craft can operate at a break-even point and large (500-1000 t) can be operationally profitable. Under study is a Kawasaki Heavy Industry concept for unloading container ships. It would be a hybrid airship with 4 helicopter rotors with a 30-ton payload.

For the future, M. Gabriel Khoury of Imperial College of Science and Technology, London, discussed the "Sunship," a solar-powered airship. The Sunship would be powered by solar cell arrays developed for satellite use such as the ones currently on the Ariel 5. Nine hours of sunshine per day would be necessary for operation, limiting use to the latitudes between 10 to 30 degrees; i.e., practically North Africa and Australia. On the basis of current airborne solar cell technology, a 50-ton payload vessel would be the smallest size feasible for solar cell weight of 0.6 kg/m^2.

A project which is supposedly on the march, with financing from European Ferries and bond and stock floating in April 1979, is the Thermoskyship, recently featured in an article in the *Sunday Telegraph* (London). Mr. Malcolm Wren (Managing Director of Thermoskyships, Ltd.) Isle of Man, UK, discussed the circular planform of the skyship that is to be used for passenger traffic across the English Channel in competition with ferries, hydrofoils, and hovercraft. A minimum payload of 6 tons would be required, with the real payoff in the 100-ton category. To be competitive, a rapid turnaround time and high usage factor would be necessary. Wren estimated about £10 million development cost and £2 million production cost for a 45-m-diam. 6-ton skyship.

Mr. Norman Mayer (NASA, Washington, D.C.) summarized some US studies that show a market potential of more than 1000 heavy lift vehicles in the 25-75-ton category, with further smaller requirements up to 900-ton capacity.

NASA has sponsored technical studies by such US companies as Goodyear, Piasecki, Aerocrane, and Grumman. Mr. Dale Williams of Goodyear advised that his company was influenced by the 1974 US Navy Postgraduate School Airship Conference and did some serious economic studies. Their studies included consulting with specialists at Sikorsky, Hamilton Standard, GE, RCA, Princeton Univ., et al., to investigate the airship as a system. Their conclusions were that there is a commercial potential for heavy-lift hybrid-type airships of a nonrigid envelope with a real VTOL (vertical take-off and landing) capability.

Prof. H. C. Curtiss, Jr., of Princeton University described work done on a 1/10 scale (12.2-m-diam.) model of the Aerocrane, a 50-ton heavy-lift vehicle consisting of a helium-filled spherical body which continually rotates by action of 4 engine-driven propellers mounted on the ends of rotor blades extending from the equator of the sphere.

Dr. Eng. Brockman (Institut für angewandte Materialforschung, Bremen-Lesum, Germany) was not so optimistic for future airships unless they were to be extremely large. His studies showed that large airships must be rigid,

and although new concepts in girder construction, bonding, and modern materials could reduce structure size and weight, the high costs of titanium, carbon fiber, turbine engines, indirect costs for infrastructure, and the disadvantages of slow speed make the airship noncompetitive with aircraft unless on the order of 600,000 m^3 in volume.

M. J. Dufour (Director of Tropica Tour, Paris, operating a tourist agency) showed a film entitled "Safaris en Balloon." An intermittent burning hot-air balloon that can fly noiselessly at treetop level can be rented for a safari in Kenya. Instead of scattering the animals, the balloonists can photograph smiling giraffes. The balloon is tracked by a Range Rover and four Masai line-handlers, who also mix the martinis and set up the tents at night. Although Dufour could see the commercial advantage of airships for this purpose, I must confess I prefer the current method and would rather go on safari in his hot-air balloon.

M. Jacques Plaignard (Institute du Transport Aérien, Paris) summarized why nothing has materialized in commercial airships over the past 15 years. He cited numerous crashes and fatalities of French, Italian, British, American, and German airships. With the crash of the German Hindenburg in 1937, the public suddenly lost faith in the zeppelin. Although several more were under construction, the start of WWII ended the 27 years of commercial German dirigible service. The sad economics of the airship is that the operating cost is high and the number of units small for use in passenger service. Wishing will not bring back the airship.

An existing commercial tethered aerostat program by TCOM division of Westinghouse is the Telecommunication Balloons used in Nigeria. TCOM uses a 10,000-m^3 nonrigid balloon to lift approximately 3000 kg of electronic equipment to 3000 m. Acting as a minisatellite, a single station can simultaneously broadcast radio, TV, and telephony over an area of 50,000 square miles.

In summary there is some effort in development of LTA as shown by TCOM, the launching of Aerospace Developments AD-500 in England earlier this year, model testing in the US and France, and the Thermoskyship project. Many studies have been completed since we reported on the future of the airship in *ESN* 30-1.

The conference registered optimism in the future of LTA. It was very evident, however, that there is a requirement by industry or government agencies for heavy investment to initiate action, and although interest is high, financing is lacking. The conference was somewhat marred by not having a representative of Aerospace Developments, London, England, and also the lack of English translation for the specialized sessions that concerned materials, structures, propulsion, and applications. Like most of aviation, progress in commercial applications of LTA would follow government development and absorption of the research and development costs. I suspect unless government agencies lead the way, the next AERALL session will still be proclaiming La Renaissance du Dirigeable. (CAPT P.F. Gibber)

CHEMISTRY

CHEMISTRY AT SWISS UNIVERSITIES

This article describes activities in chemistry and chemical research at Swiss Universities. In particular, the institutions reported on here are the Eidgenössische Technische Hochschule (The Federal Institute of Technology, Zurich, hereafter referred to as ETH), the Ecole Polytechnique Fédérale (EPFL, Lausanne), and the University of Geneva.

Zurich—ETH is one of Europe's premier technical universities. Its chemistry laboratories have been expanded greatly during the past two decades, with new buildings for physical chemistry and organic chemistry and re-modeled and expanded facilities for inorganic chemistry and for applied and textile chemistry. My hosts at ETH were Profs. Heinrich Zollinger (applied and textile chemistry) and Luigi Venanzi and Gerhard Geier (inorganic chemistry). Zollinger is one of the world's authorities in the field of textile and dye chemistry. He also served as the chief administrative officer of ETH during the last four years. Since January 1979, he has been the President of the Steering Committee of the Swiss National Science Foundation (SNSF).

Zollinger is formally in the laboratory for technical chemistry of ETH. This covers chemical engineering, poly-

mer science and dyes and textiles. The faculty of this laboratory consists of 10 professors, of whom five are in chemical engineering, three work with polymers and two (including Zollinger) in dyes and textiles. The laboratory is administered by one of these faculty members as director for a 2-year term.

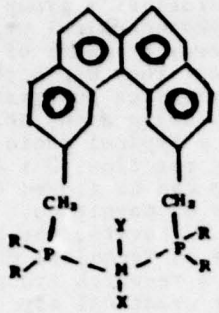
Although Zollinger has had considerable administrative responsibility, he assured me that he has always been able to maintain a research program, albeit on a reduced scale. At present, his research interests concern two areas: the reactions of diazo compounds and (in response to current topical interests) the microbiological degradation of dyes in aqueous media. In his work in diazo compounds, his group has found a new synthetic procedure for making diazonium salts from aryl cations and nitrogen under pressures of around 300 atm and is currently working on a similar synthetic procedure using carbenes or free-radicals with nitrogen. The group is also interested in the cleavage of diazonium compounds by the homolytic and heterolytic elimination of nitrogen from these molecules. In the work on the biodegradation of dyes it was found that azodyes can be biodegraded to amines. Regrettably, this is not of much practical use, because pollution of rivers by amines is just as bad as by azo compounds. In general, workers have found that dyes containing sulphonic acid groups (most azo dyes contain these groups) are very difficult to degrade. A sideline of their research is now concerned with the incorporation of the sulphonic acid groups into side chains, in the hope that this will result in improved biodegradability.

The laboratory of inorganic chemistry at the ETH has five professors on the faculty: Venanzi (my host) and Walter Schneider are full professors; Giorgio Anderegg, Rudolf Gut, and Geier are "extraordinary" professors. (The latter category corresponds roughly to associate professor in the US.) Schneider's interests involve the mechanism of the incorporation of metals into porphyrins and studies of the mechanism of the formation of iron hydroxides and their behavior in complex formation and adsorption on surfaces. Anderegg is interested in equilibria in solutions, including those involving complexes of pyrroles and crown ethers, and he is doing some research on the chemistry of technetium. Gut is studying the solutions of inorganic compounds in HF, including the behavior of silver halide electrodes in this medium, complexes of aromatic hydrocarbons and silver halides, and the copper-cuprous halide electrode.

Geier is interested in the kinetics of reactions by temperature jump and stopped flow techniques. Workers of his group have found that the methylmercury bond is exceedingly strong and, once formed, the mercury atom will coordinate only one more ligand. Also, it is possible to study the rates and the equilibrium of the exchange of this ligand under suitable conditions. The bonding of mercury to a second methyl group is less strong than the first and will undergo exchange reactions (in a matter of hours) in concentrated acids. Geier currently has three doctoral students working in this area and has recently published several papers dealing with the mercury compounds. He has also worked on the kinetics of the reactions of some lanthanide complexes, but results of this work have not yet been published.

Venanzi is the successor to the late Gerold Schwarzenbach, who held the chair of inorganic chemistry at ETH for many years. An Italian by birth and *education*, Venzani came to Zurich four years ago by way of Oxford, SUNY-Albany, and Newark, Delaware (where he was Chairman for a short period), but it appears that he is now well settled in his new surroundings. (It is not at all uncommon at the ETH for foreigners to be members of the senior faculty!) He has long been interested in coordination compounds, and his research interests have gradually tended towards organometallic compounds, with possible application in homogeneous catalysis. In their synthetic work, his group utilizes multi-nuclear NMR spectroscopy extensively. (Venanzi brought Dr. P.S. Pregosin with him from the Univ. of Delaware, where the latter had been primarily responsible for NMR work.) An excellent review of the work in this area appeared in the June 1978 issue of *Chemistry in Britain*.

Venanzi and his group of twelve investigators have recently been interested in the following aromatic-based diphosphine ligand, which is designed to force a trans square-planar configuration on the metal that is bound to it:



Complexes of this ligand are usually water insoluble, but the introduction of trifluoromethyl groups will make the complex soluble in methanol. They have been studying such transition metals as nickel, platinum, and palladium (II). In the figure above, the X is always a halide and the Y can be a halide or some other ligand. When rhodium (R) or iridium (I) is used, the Y will then be a zero-valent ligand such as CO or ethylene. They find that the trivalent ruthenium or iron will form a trigonal bipyramid structure with this ligand and that the square planar complexes will convert to the trigonal bipyramid structures when oxidized under suitable conditions. With the RuCl (NO) system bound to this ligand, oxidation goes all the way to an octahedral structure. Chlorine is a useful oxidizing agent in the presence of chloride ion for such systems.

In another area, they have been interested in the chemistry of metal nitrosyls, in which there is still some controversy about the bonding involved. They have been very much involved in studying the reactions of metal hydrides (bonded to a variety of ligands) with olefins, and they find that when the metal hydride is complexed with the aromatic phosphine (drawn above), the addition can occur, thus demonstrating that a cis configuration is not required for such additions. They have also been studying addition reactions of alpha, beta-unsaturated ketones/esters and of acetylenes with platinum compounds and determining the rates of the addition reactions by NMR spectroscopy. An interesting reaction found involves the cyclization of 5-amino-1, 2-pentene under acid conditions in the presence of $PtCl_4^{2-}$ to the conjugate acid of alpha-emthyl pyrrole. They are currently studying the scope of this reaction with a variety of aliphatic amines. The group has also combined Pt atoms containing trialkyl phosphine ligands by means of two hydride bridges and finds that this complex is capable of reacting with carbon monoxide.

Lausanne—It is obvious that in Switzerland sooner or later a Federal Institute of Technology had to be established in the French speaking part of the countty. This is now the Ecole Polytechnique Fédérale de Lausanne (EPFL). While EPFL actually claims to be older than ETH, based on connection with a school established 100 years ago, in reality the large build-up of EPL has occurred only during the last ten years. Since there was also a cantonal university (Univ. of Lausanne), however, some effort was made to avoid duplication of all the scientific faculties. Thus it was decided by the Federal Government that in chemistry EPFL should restrict itself to physical chemistry, applied chemistry and electrochemistry and that its students would depend on the Univ. of Lausanne for training in organic and inorganic chemistry.

The EPFL campus is at the edge of the city of Lausanne, with ample space and lavishly equipped buildings. Unfortunately, the budget of the Canton of Vaud has not permitted construction of the new science buildings that were envisaged and for which ground has been made available by the Federal Government, next to the EPFL buildings. Thus, some students must commute between the EPFL campus and the Univ. of Lausanne buildings in the center of town. Of the 2000 students at EPFL at the present time, very few are registered to work for a doctors' degree. However, the chemistry and chemical engineering buildings that I have seen have been designed with a much larger student body in mind, with spacious laboratories and an array of large lecture rooms that are only sparsely occupied at the present time; so EPFL is actively seeking doctoral students.

At first, the only professor in physical chemistry at the EPFL was Prof. T. Gaeumann, whose research interests are in the field of mass spectrometry of organic compounds. A couple of years ago my host, Prof. Michael Graetzel, was added to the faculty as an extraordinary professor. Graetzel, a German chemist, who comes from the Hahn-Meitner Institute in West Berlin, is a dynamic young scientist who has already made

quite a reputation for himself in research on micelle systems. At present he has a research group of eight at Lausanne working in this area and he is also a consultant to Polaroid and to Ciba-Geigy. Much of Graetzel's research is related to the possible photochemical storage and utilization of solar energy (by means of micelle systems). On the synthetic aspects he has the collaboration of Dr. Andre Braun (until recently a photochemist with Ciba-Geigy and now a 'docent' at EPFL). Graetzel has two permanent assistants on the staff: Dr. P. Imfelta, who is primarily concerned with theoretical work on micelles and kinetic theory, and Dr. J. Kiwi, who is doing research on the photochemistry of polymers, emulsions, redox catalysis and microemulsions. There are also two postdoctoral research associates, working mainly on surfactants derived from crown ethers or the tetra aza-analogues of crown ethers. They find that these compounds are very strong complexing agents for a variety of metals and, furthermore, that they are exceedingly effective quenchers of fluorescence and of photochemical processes. When these micelle-complexing agents are bound to metals that can exhibit different valences, they obtain redox micelles that are of potential interest in the photochemical generation of hydrogen from water.

The molecules especially modified for micelle work have to contain a hydrophobic hydrocarbon portion in addition to a hydrophilic charged functional group, all attached to the basic moiety. Braun, a well-known organic photochemist from Ciba-Geigy, was recently appointed to the staff of the EPFL, where he has a group of three chemists working primarily on the synthesis of these specialized molecules. Their synthetic work has been concerned with some of these crown ether analogs, micelle systems from phenothiazines and paraquot. Furthermore, since the hydrophilic portion of most micelle systems contains sulfonic acid groups, they have also been doing some synthetic work aimed at removing this functional group from the aromatic ring and introducing it on the aliphatic side chain. This is desirable because they find that the excited-state lifetimes of these micelles are too long when the sulfonic acid group is directly attached to the aromatic rings.

Workers in Graetzel's group are also engaged in photochemical utilization of solar energy by means of energy transfer processes; they use both chloroplasts and porphyrins as substrates. They find that by using a suitable micelle system, in a typical photo-induced electron transfer reaction ($D + A \overset{h\nu}{\rightarrow} D^+ + A^-$) the reverse can be slowed down by several orders of magnitude.

Prof. Ervin S. Kovats, the Director of the Laboratory of Technical Chemistry at the EPFL, has a research group working on the rather practical aspects of surface-active agents that are used in gas and liquid chromatography. Kovats provided me with reprints of two recent papers, one dealing with chemically modified silicon dioxide surfaces [*Helv. Chim. Acta* 61, 1912 (1978)] and "a tailor made C87 hydrocarbon as a possible nonpolar standard stationary phase for gas chromatography"—*Journal for Chromatography* 126, 63 (1976).

Geneva—Chemistry at the Univ. of Geneva is housed in the new, spacious four-story building that provides the 19 faculty members with excellent laboratory facilities. The University has 6000 students, 2000 of whom are majoring in the sciences. My host here was Prof. C.K. Jorgensen, who is well-known as one of the major contributors to the development of the ligand field theory and the spectroscopy of coordination compounds. During the last 8-10 years he has been involved in photoelectron spectroscopy, with special emphasis on that of solids. The objective here has been to arrive at a better understanding of the nature of the chemical bonding between metal and ligand. During the same period, Jorgensen has shifted his interest from the transition metals to complexes of the lanthanides and even the actinides. For the past several years he has been collaborating closely with Prof. Renate Reisfeld (Hebrew University), who is working on energy transfer in doped glasses. Jorgensen has published several papers on the spectroscopy, fluorescence and photochemistry of the uranyl ion (including a joint publication with Reisfeld). In our discussion he pointed out that the electronically excited uranyl ion is almost as strong an oxidizing agent as the fluorine molecule. Nuclear chemists may also be interested in a paper that he recently published in volume 34 of *Structure and Bonding* entitled "Predictable Quarkonium Chemistry." Along with

many other spectroscopists, Jorgensen has become interested in the research that his colleague Dr. M. Marcantonatos is doing on the photochemistry of inorganic chelate compounds. Although I did not have an opportunity to meet Marcantonatos, I learned that he is working with boron-containing chelates of benzoyl acetone and benzophenone and has been publishing his result in *Inorganica Chimica Acta* during the last two to three years.

Another senior faculty member in physical chemistry is Prof. E.A.C. Lucken. His research deals with radio-frequency spectroscopy—in particular, electron spin resonance (ESR). Recently he has been studying radiation damage in crystalline materials that have been exposed to x-rays. He and his group have been looking at organic molecules containing heteroatoms from the fifth and sixth groups of the periodic table and also organometalloid compounds. They are also involved in parallel theoretical work that concerns the structure of free radicals of this type. Related to this work is Lucken's interest in the biological aspects of ESR involving the trapping of free radicals in biological macromolecular systems. In this area they have been doing work on the structure of bones, where they have found that the degree of crystallinity can be determined better by ESR techniques than by x-ray crystallography. Another area of current research activity involves nuclear quadruple resonance (NQR) spectroscopy. They study molecular motion in solids by this technique and the effect of temperature on relaxation processes. They find that pulsed NQR spectroscopy, with pulsing at msec intervals, is a highly sensitive technique for such studies, provided that the position of the resonances is known. An interesting result that Lucken mentioned to me was that they find that in gallium chloride the two gallium isotopes exhibit different orientations! (This raises an interesting question with respect to the orientation of the atoms in gallium arsenide!)

I believe that the above survey will convince the reader that chemistry research at Swiss universities is not just alive, but that it is being carried on in a number of very busy and fruitful endeavors. [George M. Wyman, Chief, Chemistry Branch, US Army Research & Development Group (London)]

COMPUTER SCIENCE

FORMAL DESIGN METHODOLOGY—HOW TO DESIGN COMPUTER SYSTEMS WITHOUT REALLY USING YOUR HEAD

A most unusual conference was convened just outside Cambridge, UK, on 9-12 April 1979 by Standard Telecommunications Laboratories Ltd. (STL) a subsidiary of the International Telephone and Telegraph (ITT) Company. As the first major meeting devoted entirely to strictly formal system design methods for computer software, the Symposium on Formal Design Methodology (FDM 79) served as a forum for discussion of seven new design methods, all selected because they apply a high degree of mathematical formalism to the process of computer software design. They are therefore potentially representative of new methods that will become increasingly important and increasingly widely used in the next few years. The seven systems (three from the US, three from the UK, and one from Sweden) vary widely in approach, degree of development, and extent of prior use.

Attendance at FDM 79 was by invitation only. STL arranged the conference for about 50 ITT employees, both STL's and those of its international affiliates, and then magnanimously invited an equal number of other scientists to participate. Each speaker was a designer or advocate of one of the methods, and the actual meeting was devoted to several presentations by each speaker. One series of presentations covered the nature of the design process and how the method relates to this process. A second addressed the role of each method in the verification and validation of system design. A third dealt with the impact of the method on the management of large systems, and still another discussed the need for training users of each method. STL had apparently spared little expense to bring in outstanding authorities. Keynote speaker was Prof. M.M. Lehman (Imperial College of Science and Technology, London), and wrap-up speaker was Prof. C.A.R. Hoare (Oxford University).

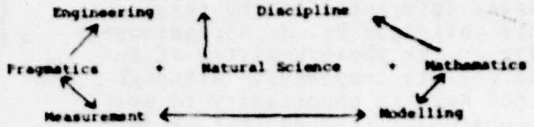
The meeting was a true symposium, not intended to be tutorial. It concentrated on the role of formality in the

system definition and design process, and on the benefits and limitations of formal methods today. The objective was to assemble and discuss those techniques for the design of large systems that contained enough mathematical formality to be representative of the next generation of design methods.

Keynote Speech—Lehman addressed the "Environment of Large System Design Methodology," opening with the point that in the US, the annual rate of expenditure for computer software maintenance is reliably estimated at $35 billion, which is 70% of the total software expediture rate. Thus, two and a half times as much money is being spent on maintenance as is being spent on new development. Formal methodologies for design of maintainable systems are therefore more important, he asserts, than for new system design, and yet the subject is hardly addressed.

Lehman then proceeded to present the most cohesive picture this writer has seen to date of his own research into program maintenance, or "evolution dynamics," as he more elegantly terms it. He started with a list of definitions of his most common terms (and these may be found near the end of this report), and he then went on to observe that although there may have been an improvement in programming productivity when measured in terms of lines of code (instructions) produced, there has not been, in the past ten years or so, any significant improvement in productivity of the maintenance function or in the effectiveness with which software effort can be transferred from the developers to a different group of maintenance people. He identified major weaknesses in the development process: weakness in methods for requirements definition and specification of software systems; absence of methods for maintenance of specifications; deficiencies in interface definition and control; and inability to predict performance, reliability, responsiveness, or changeability.

Lehman talked at length about engineering discipline *per se*, which he described as resting on three pedestals: Pragmatics, Natural Science and Mathematics. The discipline can be improved by use of measurement tools and modelling tools. He showed the relationship as follows:



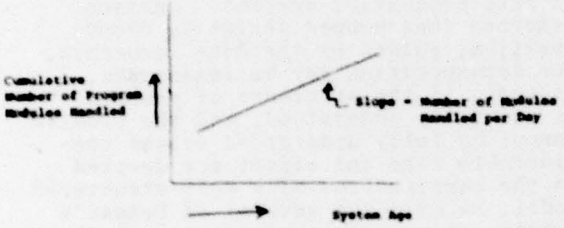
Unfortunately, as regards Software Engineering, the Natural Science component is still embryonic and the Pragmatic observations are largely confined to small systems. Lehman expressed the faith that through study of the phenomena associated with Software evolution, basic contributions to the Natural Science of software could be made. And he offered a number of "Software Laws," which, he hastened to say, might not be true laws, although to date his observations indicate that they are universal when applied to larger systems and therefore he would continue to speak of them as laws. They, and various corollaries are recapitulated herewith:

The Law of Continuing Change—Change is an intrinsic characteristic throughout the active life of any software system. As corollaries, Lehman stated that products and methodologies must be designed for change. Programs must not only be correct when first introduced but must remain correct throughout their active lives as they are revised to meet changing requirements. To the participants of this conference, Lehman stressed that formalism that fails to address or support change is quite simply inadequate for large systems.

The Law of Increasing Complexity—Program complexity (which is a reflection of decreasing structure) increases during the life of the program unless (and sometimes despite the fact that) work is done to control it. The implementation of changes usually ignores structure and concentrates on short-term cost, performance, and resource conservation. Corollary to this law, structure must be preserved as well as created; therefore, we must learn how to predict the structural impact of change. Specifically for this meeting, Lehman warned that formalism alone is inadequate: it must be accompanied, and cooperative with, structure.

The Law of Conservation of Organizational Stability—The global activity rate in a large programming project is statistically invariant. The product, the process, the organization, and the

environment are all parts of a self-stabilizing feedback system, and the rate of development or change of any such system is a function of the intrinsic system dynamics and not now a function of management decree or emphasis. Effective management is impossible without measurement based planning and control tools that do not yet exist. Improvement can come only with a better understanding of the process. Lehman showed charts of numerous large systems, which, though not individually identified, showed IBM's 05-360, Univac's Exec 8, Midland Bank's night deposit system, and others. In all cases, the curves were straight lines. That is,



the slope, which indicates the number of modules handled in a fixed time period, remains constant, often despite management efforts to change it through additional emphasis or resources.

The Law of Conservation of Familiarity—The rate of release of change content in a large programming system is statistically invariant. This may be only a special case of the previous "law," but it highlights the fact that the effort required to restore familiarity is a highly nonlinear function of the change content. That is, a small change may require almost no effort to restore familiarity, but a change which is, say, 10 times as big may require 100 or 1000 times as much effort to restore familiarity. In corollary, change content and change interval cannot be determined from programming productivity rates and resource availability alone.

The Law of Program Evolution—Large program evolution is influenced by factors which can be measured (today) only as development proceeds. Thus, the rate of change of software can only be predicted after the system has entered the maintenance phase. Statistics on its past history and knowledge of its current state are critical factors, and measurement and quantification of these factors are as fundamental to management as formalism is to the technical effort of programming.

This last and possibly most controversial law leads to the conclusion that perhaps the best solution is to avoid or bypass the large system by, for example, building distributed systems instead, and achieving performance through parallelism. In this connection, Lehman stresses that design should strive for correctness first and preservation of correctness second. Program efficiency can then come later. Stress on program efficiency too early in the process may well prevent successful development.

Lehman concluded with what was for this listener a fine recapitulation of the areas requiring research emphasis. They are: Research on methodology for requirement based design, for continuing maintenance, for management of change, for preservation and control of structure, and for life-cycle management. This was an effective and highly appropriate opening, whose themes were referred to repeatedly throughout the Symposium.

The US Methodologies—The three US methodologies discussed were SREM, HOS, and WELLMADE. Since these have already been covered in the literature, they will not be covered here. The interested reader will find a list of references near the end of this report, which also contains a fourth US methodology, SADT. Although not formally on the program, SADT was the subject of two *ad hoc* evening workshops provided by Dr. Martyn Thomas of the Univ. of Bath.

The European Methodologies—The European methodologies presented were MASCOT, MJM, MJSPDT, GAMMA, and META-PROGRAMMING. Of these, MASCOT was thought truly to meet present expectations. The Michael Jackson Method (MJM) is most impressive and widely used, but it is a method for program design and not for system design. A new product of Jackson's firm (Michael Jackson Systems Ltd., London), intended for System Design, is the MJSPDT (Michael Jackson System and Program Design Technique), which is very promising but is at present only in the early formative stages.

MASCOT (A Modular Approach to Software Construction Operation and Test)

is a development of the British Ministry of Defence Royal Signals and Radar Establishment of Malvern, Worcestershire, UK. The MASCOT project leader, Kenneth Jackson, presented MASCOT as an approach that organizes a set of cooperating parallel processes and procedures with the support of an existing software kernel that provides computer scheduling, interrupt handling subsystem control, and monitoring facilities for the system under development. MASCOT consists of formal rules for expressing the software structure of a multi-programmed or real-time system that can be independent of computer configuration and programming language. MASCOT also contains rules for design, implementation, and testing which implement a concept of modularity for real-time systems and increased control over access to data, thus yielding improved reliability. MASCOT also includes the software kernel and documentation strategy.

MASCOT relies heavily upon a network flow diagram approach, including access procedures that permit root procedures to communicate asynchronously. The methodology can be used both to de-skill design, enabling recognition of and providing design support for problems that have already been solved, and to increase the effectiveness of highly skilled people working on the solution of new problems.

MASCOT has been used on several systems and has proven very beneficial. Jackson observed that MASCOT is highly compatible with SADT and could perhaps be used in conjunction with it. The difference between the two methods at present is that SADT equates the user requirements with the final design and that the design is really only a functional decomposition of the problem. MASCOT demands that a formal flow design must be added to obtain a fully adequate solution.

MJM and MJSPDT—These were discussed by the originator, Michael Jackson, an enormously well-informed and effective speaker. Since MJSPDT is still in its formative stages, Jackson spent part of his time discussing MJM, which is used by 500 programming agencies worldwide, most of them private firms. Also, 9000 programmers are now using MJM, 1300 of whom work for ESSO. Jackson himself and his own firm have no corporate experience on large systems, but he made some fundamental points based upon experience with individual programs which, it seems to this observer, must have profound implications on the design of large systems. He advocated at length the concept stressed in his book *Principles of Program Design* (Academic Press 1975) that the data structure of the program must reflect the data structure of the problem. Only if this is true is maintenance feasible, and only if this is true will the complexity of changes to the program be comparable to the complexity of changes in requirements as perceived by the user. Otherwise, the user will request what appear to him to be minor changes and find that they are so expensive as to be impractical, thus creating enormous distrust between the developers and users of data processing systems. Jackson asserted that proper design is decomposition, guided by the data structure. The decomposition may be inadequate, however, if the structure of problem is not fully understood, and the problem cannot be fully understood unless considerable care and effort are devoted to the construction of a well-structured model. He mirrored several of Lehman's points, that correctness must come first and that certain concerns must be dealt with separately: static considerations versus dynamic; design concerns versus implementation; modelling concerns versus function; and correctness versus efficiency. He asserted that all management issues in programming actually have roots in technical issues, and above all he stressed that we must avoid the confusion between model and function. The manager, he suggests, is often so eager for results that he pushes for implementation of a function without allowing a model to be built beforehand for structural guidance. Since the technologists are often also guilty of impatience in this regard, system development failures are very frequent.

GAMMA, a development of Software Sciences Limited (SSL) of Macclesfield, UK, was sponsored in its early phases by the British Ministry of Defence and more recently by the Department of Industry. GAMMA includes an approach or strategy for design, a supporting programming language which implements the approach, and a support system—hardware and software—which can produce executable code from the language. A prototype GAMMA language exists, written in ALGOL 68R and operational on an ICL 1900 computer. Mike Falla of SSL, who made the GAMMA presentation, acknow-

ledges that GAMMA is today really a language for defining fragments of software systems and not complete systems. GAMMA does promise to improve the "modifiability" of programs, though Falla did not elaborate on this in great detail. As a formal system, GAMMA offers disciplines which will ease the sharing of modules and transportability. However, GAMMA has had problems. It seems to require highly skilled practitioners. This, and its unavailability in COBAL or FORTRAN or PL1 form, has limited customer acceptance, and this system has been used to date only for limited applications on small projects or limited software components.

METAPROGRAMMING is a metaphilosophy entertainingly if modestly presented by Professor Harold Lawson (Linköping Univ., Sweden). Metaprogramming is an attempt to apply grammars and parsing methods to structure. It has been successfully used in solving small well-contained problems. This is potentially a very important approach but is really only now in its early formative phases.

University Research—Although Lawson of Linköping and Lehman of Imperial College seemed to be the only university professors at the Symposium stressing Formal Design Methodology, a discussion among other representatives of universities served to crystallize some thoughts on research in Computer Science in Britain. Individuals present were C.A.R. Hoare (Oxford), A. Shapiro (Edinburgh), F.P. Coakley (Essex), J.A. Llewellyn (Lancaster), J.D. Roberts (Reading), G. Musgrave (Brunel), and J.C.P. Woodcock (Liverpool). From this session I found out that Hoare is engaged in important research that relates and in some sense provides a foundation for formalism in design methodology. (He described this later, in some detail.) It also became clear that strong research departments exist at Oxford, Cambridge, Imperial College (London), Manchester, Edinburgh, Univ. College (London), Swansea, Canterbury, Belfast, Warwick, Newcastle upon Tyne, Brunel, and several of the other London colleges. For a nation of Britain's size and economic strength this, in fact, is a remarkably strong showing.

Related New Techniques—Two new techniques of potential broad usefulness were described during the conference. Lawson spoke about Dimensional Flow Charts, whose development he attributed to R. Witty, and Hoare described Denotational Semantics, the results of work by C. Strachey. Both are at present desk-top methods for analysis of functions. Their presentation was a revelation to me of how gracefully intellectual issues can be fought to the death. Throughout the early days of the meeting Lawson frequently, and apparently arbitrarily, asserted that graphic techniques are superior to narrative techniques—and Hoare seemed to find it amusing to demolish these assertions with apparently unjustifiable violence. Finally, to end the mystification of the onlookers and in response to requests, each speaker provided an *ad hoc* description of his favored tool. And, of course, the future will probably be greatly influenced by some combination of the two. a) Dimensional Flow Charts offer a three-dimensional representation of what conventional flow charts really show in a single linear form. In dimensional flow charts the lines or arrows connecting related boxes or shapes can move in three directions: vertically, horizontally, or diagonally. Vertical connections indicate sequences, as they pretty much do in conventional flow charts. Horizontal connections indicate selection, including parallelism. And diagonal connections show refinement. b) Denotational Semantics, which is more ambitious, is a method that seeks to assign an abstract (or mathematical) meaning (or denotation) to every word or phrase of narrative statements. It is entirely possible that Hoare described Denotational Semantics, but all that I was able to absorb were a few examples and a great deal of civilized wit in the finest tradition of Samuel Johnson. I was certainly left with the strong impression that Denotational Semantics may well have great implications on the solution of the problem of requirements definition.

Comparison of Techniques—Long sessions of the conference were devoted to presentations by each methodology advocate aimed at displaying how each method contributed to improved creativity of highly skilled people, improved performance by low skilled people, improved management, better cost and schedule prediction, greater maintainability and easier training. With only one exception, each advocate claimed that his sytem did all these things, that analysis is good, and formal analysis is very helpful. Don Boyd (WELLMADE)

alone confessed from the beginning that he had experienced great difficulty in teaching his method. He admitted that his biggest problem is that he still doesn't know how to teach his methodology to people who believe they are already qualified designers or how to win their acceptance of the new method. As the week progressed, his frankness proved contagious, though its contagions fell far short of epidemic proportions. It was admitted that with HOS greater success had been achieved with new programmers, and the same is true of GAMMA.

Hoare's wrap-up was again richly in the tradition of Dr. Samuel Johnson (who was, I suppose, the Mort Sahl of his era), though the constant loud laughter which Hoare's witty remarks produced sometimes seemed to obscure the ideas he was offering. He pointed out that our management demands are unreasonable in that: we expect training time to be minimized and the knowledge gained to be immediately and fully applicable right after training is completed; our methods must be both evolutionary and easily standardized; they must support and enable brilliant innovation and creativity while also making it possible for the unskilled to do creditable work; they must be readily acceptable without disrupting the existing organization or way of thinking; and they must have an enormous early pay-off without any investment. He postulated an ideal world in which managers, upon observing themselves and others, might come to realize that certain basic concepts are of considerable importance, such as that it is generally helpful to understand a problem before attempting to solve it.

Hoare did indicate that the conference revealed that much research of the last 15 years is being successfully exploited in the attempts at development of formal design methods, and he offered a table that loosely identified research areas with methods and workers now producing formal design methodology results. I have provided a copy of his table at the end of this report. He noted that one of the newest and most important research contributions is in the field of communicating processes. This is the work of W. Wage of the Univ. of Warwick on LUCID.

He singled out WELLMADE and MJSPDT as potentially the most important systems described at this conference, and WELLMADE especially as conceptually the most advanced method in its exploitation of ideas of formal correctness and data abstraction. MJSPDT is important because it is syntax directed, with emphasis on parallel processing structures and system modelling ideas. These two systems complement one another to a remarkable degree, each being weak where the other is strong. In the ensuing discussion it was stated that the same is true of at least two of the currently operational systems, and that MASCOT and SREM advocates will be giving some thought to integrating with one another.

Hoare closed by quoting Dyjkstra's comment that the reason that software developments seem to fall so far behind hardware developments is that the hardware designer is constantly implementing the same old solutions in ever newer technology, while the software designer is implementing ever newer solutions, always using the same old technology. This conference offers the hope that software technology will not always stay the same.

To conclude this report, I list definitions and some other material referred to earlier:

A. *Lehman's Software Definitions*

Programming—The preparation of a complete algorithmic specification and procedure for the mechanization or solution of a computer-soluble problem.

Programming Methodology—Abstraction and formalization of methods and tools used by individuals to create programs that correctly, completely, and only solve the specified problem.

Large Program—(or large system) a program (or system) requiring the development or maintenance effort of two or more groups of people, and therefore a program (or system) whose social environment includes at least one "cultural gap" separating some of the workers on the project.

Software Engineering—an abstraction of methods, techniques, and tools used by cooperating individuals organized in groups to produce jointly a system of programs that addresses a variety of requirements, i.e., to produce a large program (or large system). (Note: A more common definition of Software Engineering fails to address the real problem of "culture gap." That definition equates a combination of Structured Programming and Inspection to a Software Engineering discipline.)

B. *Methodologies*

SREM—"The Software Development System," C.G. Davis and C.R. Vick, *IEEE Transactions on Software Engineering* SE-3, No. 1 (Jan 1977).

"A Requirements Engineering Methodology for Real-Time Processing Requirements," M.W. Alford, *IEEE Transactions on Software Engineering* SE-3, No. 1, (Jan 1977).

HOS—"Higher Order Software—A Methodology for Defining Software," M. Hamilton and S. Zeldin, *IEEE Transactions on Software Engineering* SE-2, No. 3, (Mar 1976).

WELLMADE—"Introduction to the WELLMADE Design Methodology," D.L. Boyd and A. Pizzarello, *IEEE Transactions on Software Engineering* SE-4, No. 4, (July 1978).

SADT—"SADT, the SofTECH Approach to System Development," SofTECH, the Software Technology Company, (Jan 1976).

"Structured Analysis for Requirements Definition," D. Ross and K. Shoman, *Proceedings of the Second International Software Engineering Conference* (Oct 1976).

C. *Hoare's Table Relating Research to Design Method*

Research Area	Formal Design Method Exploitation
Predicate Calculus	VCG, GYPSY, I, WELLMADE Program
Correctness	WELLMADE
Algebraic Abstraction	GAMMA, PASCAL *(1), WELLMADE
Formal Syntax	METAPROGRAMMING, TRNF, MJSPDT
Functional Definitions	SCOTT/STRACHEY, BACKUS
Graph theory	
Numerical Analysis	Wilkinson, Fox
Analysis of Algorithms	Knuth
Parallel processing	MJSPDT, PASCAL *, MASCOT
Communicating Process	LUCID, (2) Kahn/McQueen, (3)Milner

Notes:
(1) PASCAL * is the work of Welsh at Belfast
(2) LUCID is the work of W. Wage at Warwick
(3) Kahn and McQueen are at Edinburgh

[George M. Sokol, Chief, Information Sciences Branch, United States Army Research and Standardization Group (Europe)]

ENERGY

GETTING CHARGED UP IN THE UK: THE ARMY-NAVY-AIR FORCE GAME IN BATTERY RESEARCH: PART THREE - AIR FORCE

This is the third in a series of notes on battery research in UK defense laboratories. The first (*ESN* 33-5: 184) reviewed work underway at the Royal Armament R&D Establishment (RARDE), an Army lab, while the second (*ESN* 33-6:227) described programs at the Admiralty Marine Technology Establishment (AMTE), Holton Heath. This final note reports on programs at the Royal Aircraft Establishment (RAE) Farnborough, and provides a brief summary of the series of notes.

RAE-Air Force: The RAE batteries program is coordinated by a group calling themselves Electrochemistry and Battery Technology, headed by R.J. Doran. They are located administratively in the Non-Metallic Materials Branch, one of 5 branches of the Materials Department. This group was founded about 25 years ago to be, as they are now, a practicing center of expertise on batteries within MOD. They are also currently the technical orginators of a large proportion of MOD's extramural research in the battery field at companies and universities. One of the key researchers is Dr. J. Thompson, currently chairman of the Joint Services Electrical Power Sources Committee that organizes the biennial Power Sources Symposium in Brighton.

The prime commitment of the RAE group is to advance the state of knowledge relative to batteries for aircraft and guided weapons (for all three services). Also such applications as Army Portable Electronic Equipment (APEE) in all its various forms, sonobuoys, rescue and location beacons, air armaments, avionic systems, etc., are given a lot of attention. The group is also involved in quite a bit of consultative work outside these fields as well.

As an example of their cooperative work with external laboratories a joint program with the University of Newcastle upon Tyne is exploring failure mechanisms of vented Ni-Cd cells in overcharge situations. This work, reported recently at the 11th International Power Sources Symposium in Brighton, consists of basic electrode measurements to study oxygen

reduction on Cd and Ni, as well as measurements on stationary flat and sintered Cd. Actual batteries have also been studied, and overcharge characteristics, including gassing rates, have been measured on a variety of aircraft main battery types, including cells returned from use in aircraft with various forms of defective behavior. The electrolyte from defective cells is studied voltametrically at stationary electrodes to investigate the possibility of redox couples, and components of defective cells are physically examined. This attack on the problem amounts to a very sophisticated form of failure analysis. The falling voltage characteristic of defective cells has been associated with three possible failure mechanisms: oxygen recombination involving transport in both the dissolved and gaseous states, the operation of possible redox systems, and the formation of "soft" (active material) shorts. All three are found to contribute to the behavior of defective cells, but the last, "soft" shorts, usually seems to dominate.

Overall, the battery research situation at RAE is such that there is quite a large extramural program and very little basic work done in-house. The research is usually in support of particular programs at the Establishment, with most fundamental work being farmed out to universities. In the terminology used, time is about equally divided between monitoring external "research" and doing "project" work. Doran indicated that at any one time they are involved with about 50 "research" topics and perhaps 25 "projects." In the case of the basic research topics, the role of the group is to initiate, direct, and participate (to a limited extent) in the work. With the internal projects, the group may act in a specialist advisory role on feasibility, choice of battery, involvement with its development and interfacing, etc. One aspect of the work is that the group must span virtually the whole spectrum of electrochemical power systems, since almost every battery type is either currently or prospectively of relevance or interest in one of the fields of application. Doran seemed particularly sensitive that the RAE program, being based largely in extramural work, might be considered an inferior research activity. This certainly does not seem to be the case, as there is an impressive and active expertise evident in the group.

Summary: This series of three notes has attempted to review battery research in UK defense laboratories, using as examples the programs centered at RARDE, AMTE, and RAE. It can be seen that there are a number of similarities between the programs at the three labs and, of course, some significant differences. Naturally there are differences in terms of the specific battery systems under study, but there are also substantial differences in the approaches to battery R&D at the different labs. One similarity between the three is that intramural battery research effort is relatively small in scale and so the complementary extramural programs are essential. In fact, one of the indicators of MOD involvement in UK battery research is that at the recent 11th International Power Sources Symposium held in Brighton, nearly all of the British contributions, numbering 10 of the total of about 50 papers, reflected sponsorship or cooperation with one of the three labs under discussion here. RARDE and AMTE seem to do more in-house fundamental work than RAE, at least as measured in terms of direct output to the technical literature. However, this is not necessarily the best indicator, and in fact, RAE has probably the greatest indirect activity in basic work through its very extensive extramural program. RARDE has a special emphasis in the area of long-term storage life, whereas the nature of AMTE's work is to explore basic cell design.

It should be added that contact between the corresponding groups in the various establishments is maintained in various ways, formal and informal. There are committees that deal with battery standardization, and periodically there are formal meetings at which the progress of intramural programs is reviewed. (Jeff Perkins)

SOLAR ENERGY IN GREECE AND EGYPT

Because the Mediterranean countries have comparatively low latitudes and are comparatively cloudless, they are more promising locales for solar energy than western Europe or the United States. Nonetheless, I find them much more modest in their aspirations for solar energy. Typically when one talks to solar energy development people in the US, one hears plans for replacement of much of our present energy consumption. The head of solar energy research and development in Egypt told me that his country would not in the foreseeable future develop more than 6% or 7% of its energy directly from the sun, and he doubted if any other country (or at least any major country) would do better. The corresponding official in Greece told me that between 2% and 4% of total primary energy is substitutable. These countries are, however, very serious about substitution in those places where solar energy is really useful. In Greece they feel that solar energy is competitive for water heating which is now done with electricity, but not for water heating done by petroleum fuels. In Egypt they feel solar energy is competitive for all water heating. In both countries they are seriously working to make these substitutions, and it seems possible that they will be quite successful within a generation.

Egypt has no significant space heating problems; it never gets below 5°C in Cairo, and even that degree of cold is quite rare. Much of Egypt is rural and undeveloped, and the principal consumption of fuel is for cooking, but there seems little hope of using solar energy for this purpose. In Greece, subfreezing temperatures are not uncommon, so a lot of energy is used for space heating, but again it seems unlikely that solar energy will make much contribution there in the near future.

A significant difference between Greece and Egypt is the urgency they feel for the energy crisis. Egypt at present produces somewhat more petroleum than it consumes and is a net exporter; gasoline is very cheap. Greece has no petroleum or coal whatsoever, a little hydroelectric capability, and minor supplies of lignite that are being exploited for use in boilers and the like. Its use will peak in 1987, and the lignite will be exhausted early in the 21st century. The Greeks are more affluent than the Egyptians, and they have a large number of autos that consume a lot of petroleum; they have just raised the price of gasoline to more than $3 per gallon, with the expectation that this will soon drastically reduce its consumption. They are counting on nuclear energy for almost all their electricity in the future.

In Greece solar energy R&D goes on at 3 separate government organizations and in the universities. One of these government organizations is "Democritos," the Greek Atomic Energy Research agency in Athens. In the year 420 BC the Greek philosopher Democritos proposed the hypothesis that matter might be discrete (as distinguished from continuous), and while this was hardly a scientific proposal it remains the first atomic theory and is famed as such. It is therefore not unreasonable that the Greeks have named their energy agency Democritos. It started as an atomic energy agency, although it now has other responsibilities including solar energy development. The law establishing the agency was enacted in 1954, the center was established in 1957, and its reactor (open-pool, light-water) went critical in 1961.

Democritos is a large institute, with 200 scientific staff (all of whom have a BSc, and a very large number having a PhD), a technical staff of 350, and an administrative staff of 200. As with corresponding institutes in many European countries, it has an educational function and therefore has professors who direct research theses at the doctoral level, although the student's eventual degree is awarded by a university. In addition to its primary work of energy or atomic physics, the institute studies a number of fascinating things related only peripherally to these topics, including archaeology, the preservation of ancient materials, and the use of isotopes in hydrology.

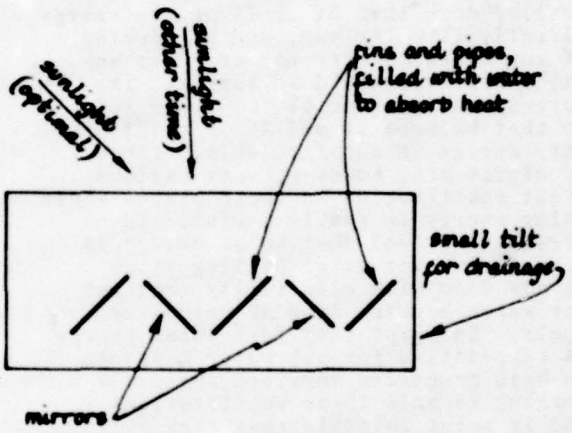
Research on solar energy is being carried on primarily under two people: Drs. Spirodonis and A. Deliyannis. The former took his doctorate in physics at the Univ. of Patras in Greece, with his thesis dealing with the construction of a solar energy converter. His primary effort now is in the development of heat pipes, used to carry heat from a solar collector to some other point. He showed me a number of these. The idea is to put heat in at one end to vaporize a liquid that travels down

through the pipe, condenses, and then returns through some porous material. As is well-known, such heat pipes have excellent effective thermal conductivity and can therefore be used in applications requiring transfer of large quantities of heat without expenditure of the energy that would be required for pumping a cooling fluid.

Deliyannis is a fascinating man. At the age of 74 he stepped down from the presidency of Democritos but continues to carry on his research in solar energy. He is now an extraordinarily young 75. He appears to have a fine international reputation, as exemplified by his relationship with the "Working Party on Fresh Water from the Sea," which has held 6 international meetings over the last many years. Deliyannis, who has been elected Chairman of this Working Party, is vigorously planning for the success of the 7th conference, which will be held in Amsterdam in September 1980. Incidentally, he holds a chair of "Inorganic Mechanical Technology" (which we would probably call Chemical Engineering) at the National Technical University.

The Greeks are particularly interested in solar stills and are currently operating the largest practical one in the world, on the island of Patinos. It has 8600 m^2 of collector area and produces 35-40 m^3 water (about 10,000 gallons) per day. In the US, this would not suffice to serve very many people, but Greeks use a good deal less water per capita than do Americans. The Greeks have a very severe desalination problem because many of their people live on small islands that have very little fresh water. They have, for example, many multi-stage flash evaporation (MSF) oil-burning desalination plants, including one of 500 m^3 per day capacity on the island of Syros. Some of the plants are used for boiler-feed water and others for drinking water. They also have two electrodialysis plants, of which one produces 15,000 m^3 per day on the island of Corfu. While this is the second largest in the world, I was told that since the largest one (in Libya) apparently doesn't work very well, the Greeks claim this to be the biggest actually operating one. It was built by an American firm.

One part of the administration building at Democritos is actually heated by solar energy. There are flat-plate collectors designed at Democritos on the roof, and the hot water from these is pumped into the radiators in the building. Whenever it becomes necessary, an automatic device switches over to heating this same water by burning oil. These flat-plate collectors are stationary, and so as the sun moves from east to west during the day, and from north to south and back during the year, they are not at optimal angles. The Deliyannis group has designed a set of mirrors to go with the collectors to increase the effective illumination throughout the year (see illustration).



The institute also operates a 10-kW power plant to generate electricity. Water is solar heated to a temperature of 95°C and then used to boil Freon (CF_2Cl_2) that runs a turbogenerator. This is an experimental project, with the Greeks doing the electrical work and a German company (Telefunken) the mechanical. The device will be tested before the end of 1979. Workers at the institute are currently designing hot-air solar heaters to be used for agricultural purposes, primarily for the drying of figs but also for drying other agricultural products, including potatoes, raisins, and ultimately tobacco. Tobacco is economically a very important crop, but it is very sensitive.

Finally, they are testing certain plastic solar collectors that are being used by the Germans for swimming pools. These collectors are made by the Volkswagon company but are being tested in Greece because the solar conditions are much better there than in Germany.

At another government organization in Athens, the National Energy Council, I talked to Dr. Carabateas, who is responsible for solar energy work. He took his doctorate in mechanical engineering at MIT. One notes that almost all of the technical people in Greece have had their degrees from American or, in a few cases, British universities. There is a small bias here: I spoke only to those who speak English and who, in turn, tend to be the people who have gone to these universities. On the other hand, there are no graduate courses in Greece. A few PhDs are given based on theses, but almost everyone who wants to study at the graduate level has to go to another country for this purpose.

The Ministry of Coordination, which allocates public funds, established a National Energy Council (NEC) in 1974 (at the time of the OPEC price rise) as an advisory body that meets about six times a year. It has a Secretariat, and Carabateas' solar energy group is within this. The Secretariat acts not only to support the Council in its advisory function; it also carries on a good deal of research. It is strongly felt that such a group cannot continue to be efficient in its advisory function if it is not active in research and knowledgeable about up-to-date technical details. As mentioned above, the Council is primarily interested in replacing electric water heaters. To do this completely would require an investment of about $1 billion; however, by doing so, the Council feels that Greece would save about $200 million per year; i.e., a five-year pay-back time.

There are some interesting problems connected with this replacement. For example, most apartment houses now use electric water heating; most of the rest use butane gas. These are extremely convenient in that each tenant is supplied with cold water, uses his own heater, and is billed for the amount of electricity or gas used. Even when there is ample room on the roof of such a building to put up the necessary solar collectors, there is a serious problem of how one allocates the cost of the hot water. If it is included with the rent, people are likely to leave the hot water running, and those that use very little hot water are likely to feel that this is very unjust. No satisfactory solution to this problem seems to have been worked out in either Greece or Egypt. By the time one installs a meter in each apartment and goes to the trouble of billing and collecting from each, the cost of such a system may be drastically increased.

The Greeks have made studies leading to the use of tax incentives and low-interest government loans for the installation of solar energy systems. There is also now a big push to get solar energy into hotels. Hotels operate especially in the summertime. Since this is the best time to use solar energy, the hotels may even be willing to pay a little more for the independence of having their own solar-energy water heaters.

The National Energy Council is developing, jointly with the German government, a 10-kW power-generating solar unit that will be used for pumping. The Council is sponsoring research at the Univ. of Patras on solar energy (see below). It is participating with the International Energy Agency in Paris in a project to design two electricity-producing plants: One, based on a power tower and the other on distributed collectors, both rated at 500 kW, both to be built at Alameri in Spain. It is now trying to raise funds for the construction of these plants. Finally, it is advising the fund-giving agencies of the Greek government on developing prototype installations for houses.

The Public Power Corporation (PPC) is the largest corporation in Greece, with sales of 20 billion drachmas (slightly over half a billion dollars). It employs 25,000 people and sells 16,000-GW hours of electricity a year, with an installed capacity of 4.6 GW (approximately 1/100 the corresponding sales and capacity in the US). Most of the generators are small compared to practice in the US, say 300 MW, although they are talking about larger nuclear reactors for the near future. Greece has some power interconnections with Bulgaria and Yugoslavia, but these are not strong. Of course, the entire mainland is interconnected, but a significant fraction of the population lives on islands, and there can be no interconnections with most of these.

The head of the solar energy group at PPC is Dr. Cassapoglou, who received his MSc in engineering from Harvard and his PhD in electrical engineering from the Polytechnion (in Athens). His official title is Administrator of Planning, and he has a number of responsibilities, including future energy sources. His group's activities in the solar energy field are mainly in the area of

measurement. For example, the amount of insolation in various places is now taken mostly from meteorological data and is not very accurate. Cassapoglou's group is getting detailed hour-by-hour data from many spots in Greece, and sees a potential for solar energy for both water and space heating, thus saving electricity in the future. His group feels it is possible (but not probable) to achieve some small power production from solar energy, especially on the islands; however, at the present time there is actually more interest in wind and geothermal energy. Plans are being made to build on one of the islands a 10-kW generator, powered by a windmill bearing a two-bladed propeller 10 m in diameter. On the island of Milos (familiar as the location of the famous statue of Venus) there is considerable geothermal potential, perhaps as much as 100 MW. Two wells have already been drilled to a depth of 1100 m to bring up hot water. The Greeks also plan to construct much larger generators (app. 4 MW) based on windmills in Crete and Rhodes, with the anticipation of supplying 25% or 30% of the needs of those islands.

I mentioned above that the National Energy Council subsidizes solar-energy research at the Univ. of Patras. This work is under the direction of Prof. R. Rigopoulis, who holds a chair in physics. He has 2 chief assistants (equal to American assistant professor) and 8 assistants (teaching assistants). Much of the solar energy research is being performed by one of the chief assistants, Dr. Yianoulis, who took his PhD in physics at Ohio State Univ. Rigopoulis and Yianoulis started solar energy research in 1975 with work on photoelectrochemical processes. Since it seemed unlikely that this could ever get more than about 1% efficiency, they have dropped it. Some 3 years ago they started looking at thermal solar processes, in particular collectors for higher temperatures (100-150°C) for air-conditioning and for production of electric power. It was mentioned above that water can be heated by solar energy to 95°C and can be used to boil Freon and then generate electricity through a turbogenerator. However, the maximum efficiency in this system is about 2%. If the water could be heated to 150°C, the maximum efficiency could rise to 8%. This is the reason why Rigopoulis and Yianoulis have been working on an improved solar collector.

Conventional collectors consist of a "selective black" surface that absorbs well in the visible but radiates poorly in the infrared. This surface is faced toward the sun, and the water or other liquid is beneath it to absorb the heat. These men use instead a surface which is black in the infrared as well as the visible, the water being passed above it, retained by a transparent plate. The sunlight passes through the transparent plate into the water, and that part which is not absorbed by the water is absorbed by the black surface of the bottom thus heating the water. It is desirable that the transparent plate be a good conductor of both visible and infrared light but a poor conductor of heat. Plexiglas (methylmethacrylate) which appears to transmit somewhat farther out into the infrared than does glass is being used; however, certain newer plastics are being examined. These two researchers have also patented a different form of collector to take advantage of the countercurrent effect. It is desirable to have the water pass back and forth in several layers. To keep heat from being conducted from one of these layers to another, air gaps have been introduced between them. Thus the sunlight strikes the incoming cool water, then an air gap, then another layer of water, and so on, and eventually the black surface at the bottom.

They are also experimenting with a solar-powered air-conditioning system that operates on the same principle as a gas refrigerator, namely using the ammonia cycle. To get adequate efficiency requires temperatures in excess of 110°C.

All of the above is sponsored by the National Energy Council, which also has a contract with Brown, Boverie et Cie, a Swiss company, to test their solar collectors, and with MAN, a German company, to test their parabolic cylindrical collectors. There is a problem always in keeping the reflectivity of such collectors high. The NEC feels that it is actually cheaper to use a Fresnel-type mirror instead of a highly polished reflector and to replace it at the end of a year rather than trying to maintain high reflectivity.

Two other people at Patras are interested in solar energy. Prof. C. Lefas in Engineering is working on Freon

turbo-generators and has patents on increasing the efficiency. Professor Psolis in Chemical Technology is working with Rigopolous and Yianoulis on a system for storing solar energy. They employ a cycle involving the sulfonation of ethylene, which gives off heat at room temperature and absorbs heat in decomposing at about 100°C.

The only other people in Greece working on solar energy about whom I learned are Prof. Komoutsos in the Polytechnion in Athens and Prof. Pappadopoulos at Thessaloniki. Each is primarily interested in the architectural aspects of houses and is working on what might be called passive systems for the utilization of solar energy, namely, modification of houses to make them more efficient in this respect.

In Egypt solar energy has been important for a long time. The Solar Energy Laboratory of the National Research Centre, Cairo, was established in 1957; the current head is Dr. Sakr, who took over in 1962 immediately after completing his doctorate in the field of solar energy. At that time the area of his laboratory was increased from 25 to 150 m^2. It has continued to grow and since 1976 has utilized 8000 m^2 (approximately two acres). Much of this territory is covered with solar collectors of one kind or another.

Dr. Sakr holds the rank of Professor at the National Research Centre which, like Democritos in Greece, gives some research degrees. On his staff he has 5 PhDs of whom 2 are "in Arab countries....," a nonchalant statement taking cognizance of the fact that Egypt is constantly helping its sister Arab countries that are weaker technologically. Similarly, of the 13 engineers on Sakr's staff, some are "in Arab countries" or are studying abroad. As in Greece, most of the leading scientists took their graduate degrees outside of Egypt. Whereas most of the Greeks went to the US or England, many of the Egyptians went to Socialist countries.

The Solar Energy Laboratory has four main targets: 1) low-temperature applications, including water heating, desalinization, and agricultural drying; 2) moderate-temperature applications, including small-power generators, cooling, and refrigeration; 3) power generation, including heliostat concentrating systems; and 4) basic research, including coatings and the like. The laboratory already has some new developments to its credit in each of these four domains.

Sakr and his staff have done a systems analysis of four feasible methods of heating water in the home. One is to use a very elementary device called a Brimas burner, burning kerosene; the second uses butane gas; the third is an electric heater; and the fourth uses solar energy. Comparisons were made on systems capable of heating 45 m^3 (roughly 12,000 gals.) per year; but in the case of the first three the calculations assume 30 m^3 per 2/3 year, since during the hottest months of the summer no water heating is necessary. The initial cost is highest for the solar energy heater, but if one computes the total cost, including fuel, the comparison is very favorable to the solar heater, which also has social advantages, since this hot water is available year round, free, for things like dishwashing, which may improve domestic life. However, it is clear that there is a marketing problem. At present the Egyptians have a joint effort with industry, having given contracts to Arab contractors to manufacture the domestic heater to sell at a cost of £150, and they are now in the early stages of the manufacturing process.

The Solar Energy Laboratory also has cooperative programs with the US, with W. Germany, and with Canada. The US project involves a heliostat-concentrating system. The heliostat reflects light onto a curved mirror of 9 m dia. The personnel of the laboratory are very proud of having built this mirror themselves from 2500 flat-plate glass mirrors that are individually focused so as to pass the solar energy on to a small black collector. With Canada they are developing a flat-plate heater for agricultural product drying. With W. Germany the Laboratory has several projects: One using parabolic mirrors to heat water for power generation (a Freon system); another using flat-plate collectors for absorption cooling (using the ammonia system); and a third, distillation for desalinization purposes.

The absorption cooling work is being done in connection with Dornier Systems Co. (Friedrichshafen, FRG) under the direction of Ingr. Raymund Hause. The solar cooling plant has a collector area of 25 m^2 and a cooling power output of about 3 kW for about 5 hours per day, giving therefore a total power

output of about 15 kWh per day. The evaporator has a cooling capacity of about 1 kWh, so the system must store up to 10 kWh during the remainder of the day, which it does in the form of liquid ammonia. The storage box has a volume of about 10 m^3 and a storage capacity of about 300 kg of food, which can be cooled from 30°C to 6°C or 8°C in about one day. Thus the cooling capacity is also roughly 300 kg per day of food.

Finally, some work on solar energy, involving some rather fundamental physics of photovoltaic cells, is in progress at the Univ. of Alexandria Research Center (UNARC). This will be discussed in a separate article on UNARC. (Robert E. Machol)

FLUID MECHANICS

FLUID DYNAMICS AT THE TECHNISCHE HOGESCHOOL DELFT

The Technische Hogeschool (Technical University) at Delft has historically been an important center for fluid mechanics research. The first chairholder in fluid mechanics was Prof. J.M. Burgers, who during the 1950s came to the US and settled at the Univ. of Maryland. On his departure from Delft, Burgers' chair was divided into two: one of the new chairs going to Prof. L.J.F. Broer and the other to Prof. J.O. Hinze. Broer subsequently left Delft to accept a chair in theoretical physics at the Technical University at Eindhoven. Upon Hinze's recent retirement, he was succeeded by Prof. G. Ooms, who came to Delft from the Royal Dutch Shell Laboratories in Amsterdam.

Ooms' undergraduate studies at Delft were in the area of theoretical physics; under the well-known Prof. R. Kronig, he then completed the Dutch equivalent of a Master's degree with a research project involving the quantum mechanical study of the interaction of radiation with matter. After two years' service with the armed forces, Ooms joined the Royal Dutch Shell Laboratories. He completed his PhD studies under Hinze in an investigation of fluid mechanics of a core annular flow. This problem was naturally of great interest to Shell and subsequently became the subject of a patent held by Shell.

Ooms' study of core annular flows involved the flow of a core of oil on a rather thin film of water inside a pipe. The motivation for the study was to provide a way of transporting oil through a pipe with minimum energy loss. Specifically, the oil film outside the water would provide a low viscosity medium that would allow the oil to be pushed through the pipe with minimum energy dissipation for a given rate of flow. Because the specific gravity of oil is somewhat less than that of water, if the oil and water combination were at rest within the horizontal pipe, the oil would float to the top of the pipe and the water would rest on the bottom. Thus no water film would surround the oil to provide lubrication for the oil to move easily through the pipe. However, if the water once surrounds the oil during oil flow, it would somehow continue to surround the oil. It was the mechanism involved here that was the subject of interest.

Ooms studied the stability of concentric oil and water flows within a cylinder with respect to rotationally symmetric perturbations and found that there are always modes of perturbations at reasonably high Reynolds numbers that are destabilizing. He thus reasoned that the interface between the water and oil would form a ripple. However, if this ripple were purely sinusoidal, it would not provide the restoring force that would keep the oil from floating to the top surface of the pipe during flow. By observing such flow, he found, however, that the ripple was not sinusoidal but more or less saw-toothed in nature with the steep part of the saw-tooth facing in a downstream direction and the shallow part providing a hydrodynamic planing surface much in the manner of a Kingsbury thrust bearing. Observations also indicated that the ripple was not rotationally symmetric but was helical with an azimuthal periodicity of unity. The observed ripple wavelength of the interface between water and oil was comparable to the diameter of the pipe.

It seems that the water film about an oil core is very effective for efficient transportation of very viscous crude oil. An additive is introduced into the water, so that the water will

continue to wet the pipe walls, thus make restarting possible in case of pump failure. The amount of water used is roughly 3% of the total amount of oil that flows, and this small amount of water need not be removed at the refinery before the refining process begins. It is necessary to observe certain precautions in introducing the water and oil to a pipeline. If the water and oil that are introduced into a pipe do not have matching velocities at the interface, a shearing layer instability will result which will in turn cause droplets to form and spoil the water film.

The system has been tested at Shell in a 1-km long 8-in.-diam. pipe with very short bends, and it was found that the system was successful with the water flow as little as 1% of the total flow. Ooms said that a similar system had been working in California for some years on a pipeline 40 miles long. It is now intended to use this system in Oman to transport crude oil to ports. Such a system is far preferable to using a suspension of oil and water, a system that also requires less energy for the transport of the oil but results in so much water in the mixture that it must be removed before refining.

At Delft, Ooms is continuing his study of core flows using a solid rippled core, so that he can measure the force on the rippled surface and compare this with finite difference calculations of the flow field.

Another subject of interest to Ooms is the problem of plumes from smoke stacks, or, more fundamentally stated, jets in cross flow. It is intended that detailed measurements of the velocity distribution in jet plumes be carried out in order to infer the entrainment of the surrounding fluid into the plume and the drag force caused by the plume on the surrounding flow. In addition, pressure forces about the envelope of the plume will be studied. I also saw an experiment that was being set up to study coherent turbulent structures and bursting in a boundary layer tunnel of cross section 0.7 × 0.9 m with a flat plate in the center 6 m long. The maximum flow capability in this tunnel is 40 m/sec. In another low turbulence tunnel of cross section 0.4 × 0.6 m, with maximum velocity of 15 m/sec, a study in transition from laminar to turbulent boundary layer flow was being set up, with a vibrating ribbon to provide the excitation for the transition. In still another low turbulence tunnel of cross section 0.9 × 0.7 m, with a maximum flow velocity of 40 m/sec, preparation of a study of the wake from a cylinder transverse to the flow was in progress. At this time, the compressible flow study facilities are inactive.

In another flow laboratory I observed some interesting experiments that were being conducted by Dr. Allan K. Chesters. One of these involved self-excited waves in oscillations in flow in flexible tubes. Another study involved laser Doppler velocimeter measurements of flow in blood vessels at junctions, with the purpose of evaluating the shear stress at the leading edge of a junction. It is known that at points of maximum shear stress the lining of blood vessels is sometimes ripped away and a site for the formation of plaque is formed. In a third investigation, the formation of bubbles in boiling water at surfaces and the oscillations of bubbles were being studied. It was found that bubbles form at a defect in the surface, and, contrary to usual ideas on the matter, it is also found that the bubble is attached only to the edges of the defect and does not form a hemispherical surface unless the bubble formation rate is very small. If the surface is extremely smooth, there is no favored site for the formation of the bubble, so the bubble then forms at very high temperatures, in which case an explosion ensues.

The staff of the chair in fluid mechanics consists of about seven senior colleagues corresponding to research associates and a lector, who corresponds to an associate professor in the US. Some idea of the salary level of the faculty at Dutch universities can be gleaned from the relevant figures for a lector or associate professor of 75,530 to 108,306 DG per year or $38,933 to $55,828, respectively, and a professor from 85,367 DG to 134,045 DG per annum, or $44,004 to $69,096, respectively. (The cost of living in the Netherlands is approximately 50% higher than that in the United States.) In the past, professorial appointments were made for life by the Queen of the Netherlands, but according to a new law now being enacted, professorial appointments will be made according to civil service rules, and there will

be more constraints placed on the functions of the professor in terms of reporting to deans and other administrators. In another change, the "lector" rank will be abolished, and individuals who would have held this rank will be called "professor." New appointments will be made on the lector scale of salaries, and only selected professors will proceed to the higher levels of professorial pay. As for students, PhD candidates are given job appointments for four years by the university and their support is limited to only those years. It is the duty of the professor to make sure that qualified students finish their studies within that time limit.

In summary, the Technical Univ. of Delft reflects the large support given it by the Dutch government in funding and materials and will no doubt continue to perform quality research in science and technology. (Martin Lessen)

THE INSTITUT FUR HYDROMECHANIK AT THE UNIVERSITY OF KARLSRUHE REVISITED

Under the direction of Prof. E. Naudascher, the Institut für Hydromechanik (IfH) at the Univ. of Karlsruhe is organized into three departments: The Dept. of Hydraulics, headed by Naudascher; the Dept of Fluid Mechanics in Hydraulic Engineering, headed by Prof. H. Kobis; and the Dept. of Mechanics of Turbulent Flows, headed by Prof. F. Durst. I had visited the Institut two years ago (see *ESN* 31-4:160).

Since Naudascher, whom I had met during the previous visit was unavailable, I was given a tour through the facilities and the programs of research by various members of his staff.

The considerable funding that the IfH had been justifiably receiving under a large grant from the Deutsche Forschungsgemeinschaft (German Research Society) was to result in fundamentally oriented, though applied research. I was therefore prompted to see what progress had been made and, happily, I was shown developments in all of the areas previously described.

Dr. Engr. Andreas Richter showed me around the Hydraulics Laboratory, which contained a number of open channels for the study of sediment transport, contaminating plumes, overflow crests, and the like. An installation in a channel 1.80 cm wide, 60 cm high × 20 m long modeled power-plant cooling water flowing into a river. Flow volume rates of 500 liters/sec can be supplied to the primary flow in the channel, which also can be tilted to a slope of 1%. Roughness elements on the bottom of the channel simulate bottom conditions in a river. A volume rate of 20 liters/sec at a 20°C temperature difference from the main flow can be supplied in a secondary flow to simulate the power plant efflux. The head supplied to the water in the channel can be automatically regulated within ±1 mm. Data obtained from the channel are used to check the accuracy of a turbulence closure model by Dr. W. Rodi, who is engaged in the theoretical modeling of pollution in rivers. His model uses a turbulent viscosity and a turbulent thermal conductivity. Turbulent viscosity is assumed to be proportional to the turbulent kinetic energy density squared divided by the dissipation rate. The turbulent conductivity is presumed to be proportional to the turbulent viscosity. The factors of proportionality in both cases are evaluated from experiments related to the flow under study. Rodi's models include detailed temperature and density considerations of the circulating regions in the flows, stratified regions, and regions of vertically well-mixed flows. Each of the regions requires a different level of approximation in the model.

Some interesting experiments in the laboratory were concerned with modeling self-induced oscillations in hydraulic systems. One such installation was a combination of a regulating valve and a gate valve causing harmful disturbances in the flow. The Hydraulics Laboratory also has a cavitation tunnel with flow rates at 200 liter/sec and a test section 50 × 30 cm in cross section. This tunnel was a gift of the Aerodynamische Versuchsanstalt (AVA) of the Deutsche Forschungs-und Versuchsanstanstalt für Luft- und Raumfahrt (DFVLR) in Göttingen.

I was next shown through the Polymer Laboratory by Dr. Engr. Rolf Kleine, who is studying turbulent flows with polymer additives. Two such additives, polyoxyethylene and polyacrilimide are being studied with respect to their effectiveness in reducing drag and their resistance to degradation. As can be

gleaned from the structure of both of these polymers, the polyoxyethylene is more effective than the polyacrilimide although it resists degradation less. The polyoxyethylene has a somewhat linear structure whereas the polyacrilimide has bigger side chains that are also cross-linked. For the same molecular weight, the linear structure is more effective in resisting a rate of deformation of the carrying fluid so long as it remains unbroken; however, because the structure is narrower, it breaks more easily. Experiments with pressure drop measurements along a tube indicate the effectiveness of the additives by flow that is circulated around a closed loop plus the degradation of the drag inhibiting properties of the additive. It is hoped that additive introduced into a porous medium may improve the efficiency of secondary oil recovery. Apparatus for the study of pipe flow with additives up to Reynolds numbers of 50,000 and laser Doppler anemometry are part of the complement of this laboratory.

Prof. Franz Durst discussed the current activity in laser Doppler anemometry at the Institute. A recent accomplishment in this regard was the measurement, on behalf of a consortium of the 18 largest shipbuilders in the world, of the boundary layer about a ship while at sea on a trip between Europe and Africa. It is projected in the near future to utilize laser Doppler velocimetry to measure details of the flow upstream of the propeller. Durst has also demonstrated that he could apply laser Doppler anemometry to measure flow conditions at a distance of 28 m from the instrumentation. He is projecting to perform wind velocity measurements for the Bundesamt für Wehrtechnik und Beschaffung at distances ranging from 1000 to 1500 m. Light scattering techniques have also been developed to measure the combined velocity and size of entrained particle flows. Particle sizes are obtained by using the intensity of scattered white light, whereas the velocities are obtained by the Doppler shifting of laser light. New circuitry developed at the Institute now separates high and low frequency components of a signal from laser Doppler anemometry over a range of 1500 Hz to 50 MHz. The usual frequency ratio between signal components that require this sort of separation is 1:100, but this equipment will work with mixed signal components with a frequency ratio as low as 1:10.

A joint program between Karlsruhe and Lehigh Univ. in flow-induced forces on structures is being financed by the Volkswagen Foundation. The purpose of the study is to identify factors or instabilities leading to flow-induced vibrations and to identify the susceptibility of structures to such vibrations. (Martin Lessen)

MATERIAL SCIENCES

PRACTICAL MATERIALS PEOPLE AT LEICESTER, LOUGHBOROUGH, AND LEEDS

(Key Words: epoxies, polymers, adhesives, corrosion, protective coatings, metal coatings, anodization, powder metallurgy, refractory metals, ceramics, ion sputtering, surface defects, field ion microscopy, oriented films, piezoelectric polymers, PVDF)

In the mid-1960s some of the technical colleges in the UK were reinstituted as Polytechnics or, if academically qualified, given university status (see *ESN* 33-6:203). Thus, the college in Leicester became the City of Leicester Polytechnic. The college in Loughborough became the University of Technology. In about the same time period, various of the universities were urged to expand their educational and research capability to meet the growing need for science graduates. This was the case for the University of Leeds, which itself began as a technical college but became a university in 1905.

Leicester, Loughborough, and Leeds have a number of common features. All three have strong commitments to applied research and interact with private industry in a number of ways. All actively seek and receive research funding from industry, which in some instances are cooperative programs between scientists at the school and in the company laboratory. The staffs serve industry as consultants and many of the students, both undergraduate and graduate, have "sandwich" curricula where they will spend from a few months to a full academic year working in industry. Funding is also obtained from the Science Research Council and the Ministry of Defence.

The Polytechnic and the two Universities lie in the heavily industrial Midlands, so their involvement with industry is easily understood. From their beginnings, they produced the engineers

and scientists necessary for continuous industrial growth and innovation. Today the schools are involved with industry throughout the UK, Europe, and as far away as Saudi Arabia, Iraq, and South America. Many of the research staff remarked how much they enjoy their involvement in the technological "real world."

At the Leicester Polytechnic we visited the School of Chemistry. The department head is Dr. J.M. Pollock, who was on sabbatical, and so individuals of the senior research staff served as acting head on a rotating basis. During our visit, the acting head was Dr. John Comyn, who described his studies on the interaction of water with epoxide polymers. This research is aimed at the effects of water on epoxy adhesives and epoxy matrix composites. By investigating the sorption of water by epoxies, he has determined diffusion coefficients, activation energies, and solubilities. The uptake is Fickian and follows BET type III adsorption. Comyn believes the water is clustered in the polymer, presumably at polar sites (some of which may be ionic impurities). Currently, he is trying to confirm that clustering occurs. Also, he is extending his experiments to commercial, epoxy-based adhesives, i.e., the structural adhesives used in aerospace construction. He finds the same diffusion coefficent and solubility for these adhesives as in the simple epoxies even though the adhesives contain elastomeric toughening agents and other additives. In future work, Comyn plans to determine the mechanical properties and water absorption behavior of free (unbonded) adhesive films. Concurrently, work will be done on the strength and moisture resistance of steel joints bonded with these adhesives.

Dr. D.M. Brewis for the past twelve years has been investigating the adhesion of polymer films of polyethylene to themselves and to metal adherends. He has been looking into the effect of surface treatments on adhesion and is convinced that a low level of surface oxide, about 5%, gives a significant increase in adhesive strength but that above this amount the effect levels off. It is generally difficult to distinguish whether the introduction of reactive sites on a surface enhances adhesion by promoting chemical bonding between adhesive and adherend or whether the effect is caused by some other factor such as a change in the cohesive strength of the polymer surface region. Brewis has presented evidence that the increase in adhesive strength that he observes is solely due to interfacial chemical bonding.

Dr. R.H. Dahm has been doing some interesting work on the surface treatment of polytetrafluoroethylene (PTFE). The polymer surface is polarized 2 V (cathodic) in an aprotic solvent like dimethylformamide containing tetrabutylammonium salt (TBA) as the electrolyte. A metal probe is pressed against the PTFE surface, and as the polymer is reduced a carbonaceous layer spreads laterally along the surface from the electrode probe. The carbonaceous layer is conductive, and Dahm believes the carbon structure is intercalated with TBA, which acts as the charge carrier. Loss of the TBA or dilution by absorbed water from the air sharply reduces conductivity.

The first visit at Loughborough was to the Department of Materials Technology, headed by Prof. I.A. Menzies. In a discussion with Menzies over morning coffee, he stressed how important funding from industry is to his department and the University as a whole. It supplements the ever-shrinking funding from the Government, especially for the purchase of high priced equipment. A case in point is their recent acquisition of a scanning transmission electron microscope (STEM) that has a resolution capability of 50 Å. The current price for this toy is about $250,000. Getting that kind of money together must be done jointly with other departments and can involve a good bit of diplomacy.

We also discussed the scarcity of students at undergraduate and graduate levels. Menzies feels this reflects the lack of technical jobs in the UK and the low salaries being offered for those that exist. Nonetheless, he advises prospective students to go ahead and work for a degree(s) which, in the last resort, can get them a well paying job outside the country.

Menzies' scientific career has been largely devoted to studies of corrosion, so it is not surprising that much of the work in the Department is corrosion related. Drs. M.E.O. Richardson and David Gabe are looking at protective coatings and corrosion mechanisms. Richardson's work is principally on organic coatings and Gabe's on anodizing and electrochemistry.

Richardson investigated the friction and wear of polymers and the mechanochemistry of polymer surface degradation when he was at Brunel Univ., (Uxbridge). He is continuing some of this work but currently is investigating the chemistry of polymer curing by ultraviolet light and the mechanical properties of cured films. He recently started work on the fracture behavior and heat transmission characteristics of structural foams.

Richardson is also interested in glass and graphite fiber reinforced epoxies and the effect these reinforcements have on the molecular structure of the surrounding polymer matrix. The extent and even existence of such filler effects is strongly contested, but Richardson believes there is some kind of "sphere of influence" in the polymer surrounding the filament and hopes to demonstrate its existence by an acid etching technique. Etching reveals the nodular microstructure of the polymer, and he expects that the size and distribution of nodules will differ in the immediate vicinity of the fiber.

Gabe, in collaboration with Richardson, has studied the formation, structure, and electrochemistry of phosphate conversion coatings on zinc. More recently, Gabe has been studying the corrosion of indium-cadmium-lead bearing, which he thinks involves the chemical breakdown of additives in the lubricating oil to acidic products that attack the metals.

In his work on anodization, Gabe is using alternating current, which has the virtue that anodizing occurs at both electrodes simultaneously. He believes that certain additives to the bath can suppress unwanted cathodic reactions. In another area, he is investigating the kinetics of the process involved in the use of rotating disc electrodes for removing metals from electroplating baths. The electrochemistry of stationary electrodes is difficult enough but becomes inordinately complex for rotating electrodes. Gabe hopes to define the conditions for selective removal of metals from solutions containing various metallic ions.

Dr. David Coleman, also in the Department of Materials Technology, heads an active powder metallurgy (PM) group. This technology of compression molding metal powders followed by sintering can produce gears, cams, sprockets, etc., much more cheaply than conventional machining and still be close to dimensional tolerances.

Coleman's group is working in five areas of PM research. The largest effort is in tool design, especially for complex parts, where, because of uneven pressure distribution, the powder compacts to different densities. The group is developing instrumented (strain gauge) tools to monitor pressure. Coleman and Gabe are investigating the resin impregnation of PM parts to increase the strength of the "green" (unsintered) and sintered part. The polymers are the anaerobic curing type similar to the quick setting adhesives used for household repairs. The cure reaction of the anaerobics is inhibited by oxygen, but within the porous PM component the available oxygen is quickly consumed and the polymer hardens and bonds the particles together. The PM group has developed test methods for the strength, stiffness, and density of green PM parts. They expect to develop engineering design data and to use these data in the development of resin-impregnated PM parts.

The fourth and fifth areas of Coleman's work are somewhat outside conventional PM technology. He is beginning work on hard metal parts made of tungsten and titanium carbides cemented with cobalt alloys. These materials are used as tools for cold forging and are subject to sudden failure. Coleman is finding that failure initiates from surface fatigue flaws. In another area, he is working on ceramic powders, ZrO_2, MgO, Al_2O_3, and SiC, used to make melting pots for special alloys. The molten metal and slag attack the ceramic, and Coleman is looking into the morphology of the region of penetration and attack for clues to the processes involved.

We next visited the Department of Physics of the University of Technology, where Dr. J.M. Walls has a strong commitment to industry. He runs an analytical service group that conducts surface analysis using Auger, photoelectron and x-ray spectroscopy for about forty industrial companies. The fees obtained are a major part of the group's funding. Walls feels that in offering this service he has an opportunity to see where the problems are in industry and at the same time develop new analytical techniques.

The work in Walls' group goes far beyond that of an analytical service. In their basic research they are much concerned with damage done by ion-sputtering of surfaces to remove contamination. They observe sputtering

damage done to field ion emission tips which, in a field ion microscope, reveal the detailed atomic arrangement in the tip surface. They have demonstrated that sputtering obliterates any detectable surface crystal structure. Along with this work, they are trying to improve field emission (FE) sources for electron microscopes. The resolution possible with FE sources is considerably better than that with thermal emission sources. Walls is looking into the effect of various gases on emission to determine which can be tolerated in the microscope and at what concentration.

The theoretical work in Walls' group parallels their experimental studies. They are trying to analyze how a specific surface feature such as a step or lattice defect is altered as the surface is sputtered. Also, they are working on the theory of field ion microscopy.

At the University of Leeds, we discussed the current polymer research in the Department of Physics with Prof. Ian Ward, who is well known for his work on the crystal structure of polymers and the development of ultra-oriented polymer fibers (*ESN* 33-3:96). The best example of these fibers is highly drawn polyethylene in which the polymer chains are oriented in the draw directions. Polyethylene fibers with moduli as high as 10^2 GPa have been obtained.

We were rather surprised to find that Ward has gone into pilot plant production of high modulus polyethylene fibers in a large ground-floor room of a Physics Department building. It is somewhat unusual for a university to become involved in the production of a new product at the pilot plant level, but Ward feels it allows him direct involvement in the development of applications for this novel fiber. He is producing spools of continuous filament and is supplying (selling) them to interested research groups. The filament that Ward is producing has a modulus of about 60 GPa, much lower than the ultimate modulus achievable with oriented PE. However, he states that the ultra-high modulus fibers cannot be made by continuous production methods. Instead, multiple drawing or extrusion operations are required which, in Ward's opinion, can only be done by batch processing and can lead to short fibers rather than continuous filament. Therefore, compromise in modulus is necessary in order to have a commercially viable process of producing filament. The PE filaments being manufactured at Leeds are surprisingly tough, having 5-10% elongation to break. They will undoubtedly find application as reinforcement in polymer matrix composites. Ward reports that they also show promise as reinforcement for cement.

Ward is by no means so preoccupied with PE filament production as to neglect basic research. Currently, he is concerned with the orientation of highly drawn nylon and polyester. Unlike PE, the orientation of these polymers seems to involve elongation of molecules in the amorphous region, and the crystalline regions appear to be simply imbedded in oriented amorphous polymer. So far, the observed increase in modulus is rather modest: of the order of two fold compared to the undrawn polymer. However, Ward pointed out the importance of molecular orientation to properties other than stiffness. Notably, these are a reduction in moisture permeability and the development of anisotropic thermal conductivity.

In the area of polymer fracture, Ward has just completed a study of the effect of molecular weight (MW), on fracture toughness of polystyrene. He finds an increase in toughness from essentially zero to 1.2 kJ/m^2 in the narrow MW range of 4×10^3 to 6×10^3. Two competing effects appear to be involved, i.e., an increase in crazing stress and an increase in the yield zone size.

Our final call of this tour was to Dr. J. Davies in the Department of Physics at Leeds, who has been investigating the piezoelectric behavior of polyvinylidene difluoride (PVDF). This surprising polymer, after being poled in a strong electric field, exhibits piezoelectric properties, i.e., when deformed by pressure it becomes electrically polarized and can thus generate an electric field. So far, no one has been able to explain why PVDF is electroactive, but there are many workers around the world, including Davies, trying to unravel the mechanisms involved. He believes it is related to the crystal structure of the polymers. In a related study, he is working on the formation of PVDF by solid state extrusion. He finds that the extruded polymer can be poled and shows better piezoelectric properties than the conventional thin film PVDF. The poling of the extruded polymer is done at

EMI Central Research Laboratories (Hayes, UK) who are providing financial support to Davies for the extrusion work. EMI has recently produced a thick (700-μm) electroactive PVDF film that has a greater electrical output than the 10-μm conventional film. Because of proprietary nature of the work, Davies could not reveal details regarding his extrusion process. (Willard D. Bascom)

UNARC, EGYPT

Dedicated readers of these notes will recall that the Science Center in Alexandria, Egypt, was mentioned earlier (*ESN* 30-9:405) with an apology for failing to supply a fuller report; that deficiency is now being remedied. The official name of this center is the Univ. of Alexandria Research Center (UNARC), and it is indeed an unusual and fascinating place. UNARC was conceived as a center of excellence, and it seems well on its way to fulfilling that concept.

The Director and moving spirit behind the Center from its inception has been Dr. Abdel Rahman El-Sadr. Originally trained as a surgeon at the Univ. of Cairo, he has done postdoctoral work all over the US and Europe. He tells me, "My English was spoiled by spending so much time in the US," and I could believe it. In a country where most of the citizens are dark-skinned, he is one of the large minority who is quite fair; and with his wavy shock of snow-white hair and his distinguished mien he looks like an Oxford don. Although he still performs surgery occasionally, he has been an administrator since 1960, first as Dean of the Medical School, then as Vice-president for Research and Graduate Studies of the Univ. of Alexandria.

In his position as Vice-president, Sadr found great difficulty in changing anything at the University. He therefore conceived of the Center as a means of bringing about changes. Discussions about his idea with UNESCO (United Nations Educational, Scientific, and Cultural Organization) and UNDP (United Nations Development Program) started in 1968. The Center itself began in January 1972, the month in which Sadr reached the compulsory retirement age of 61. In May 1974 he was called out of retirement to take over as Director, when the Center was experiencing great difficulty. Since then the Center has grown dramatically. It now occupies a four-story building with 1700-m^2 floor space. Immediately next door under construction is a 7000-m^2 seven-story building that will be completed before the end of the year.

In accordance with the doctrine of building a center of excellence, the facilities themselves are excellent. The offices are comfortable; the laboratories are well-endowed; there are meeting rooms on each floor; a large auditorium on the ground floor with facilities for simultaneous translation; a computer set-up (which does not yet have a computer); and the like. The biologists have a scanning electron microscope, the physicists have all sorts of digital electronic equipment, and in general the environment is conducive to excellent research. When the new building is completed and fully occupied, there will be a staff of approximately 100 faculty, 350 pre- and postdoctoral fellows, 50 people manning the computer and data bank center, 50 technical staff, and 50 administrative and secretarial staff.

It is planned to operate this large Center on a budget which is incredibly modest by American standards. This is because most of the scientific staff will be employees of and paid by the Univ. of Alexandria. They will be given additional stipends, but faculty salaries are quite low. The total expenditure of the Center since its founding in 1972 has been about $3,000,000 of hard money obtained from UNESCO and UNDP, plus about 4 million Egyptian pounds (about $5.8 million at the official rate or $5.3 million at the free-market rate) obtained from the University. This money has procured a significant and growing library and all of the scientific equipment and has supported the academic staff, currently numbering about forty. Of this forty, about one-third hold the rank of professor of the University, another third hold the rank of assistant professor, and the remainder are postdoctoral. It should be noted in passing that the Egyptian system of promotion to professor is similar to that of America, in which a man is promoted on his merits, and unlike that of most of Europe, where the professorship can only be obtained when the previous occupant of the chair has vacated the position.

The UNESCO support will run out this year. There is at present a proposal to sustain it for two more years at the rate of a quarter of a million dollars a year, and the Center is quite optimistic about having this support. There are also a number of other proposals out to other non-Egyptian organizations, of which some, doubtless, will be funded. But basically this is, and will continue to be, an Egyptian organization. UNARC's primary objective is to upgrade postgraduate research at Alexandria Univ. If it succeeds in doing this, it might become a model for other universities in the country.

The Center also has a number of secondary objectives, including: interaction with international scientific institutions; to act as the link between science and technology transfer for Egypt; to create a doctoral and postdoctoral planning institution; and to participate in technology development for Egypt in industrial, agricultural, health, education, and environmental activities. In addition, there are a number of fascinating objectives besides the usual words about breaking down barriers between disciplines. For example, there are explicit desires to separate age and seniority from leadership and to minimize administrative and teaching duties which might interfere with research.

The technical personnel consists of a permanent staff and a temporary staff. The appointment of a permanent staff member is taken very seriously, and thus far none have been appointed. Both temporary and permanent staff members come from the ranks of the University faculty—at the present time from the faculties of engineering and science, and there are links with medicine. There is also the hope soon to have members from the faculty of commerce. Every member of the staff must maintain a teaching load of 3 hours a week in his own faculty. He is paid an extra 75% over and above his usual salary and it is hoped shortly to raise this to 100%. However, since faculty salaries in Egypt are incredibly low, this is not very much. In the future, if the individual scientist can write research proposals and obtain outside funding (and "outside" means either the Egyptian Academy of Sciences or non-Egyptian organizations), the Center hopes to be able to allow him to earn up to 200% over his basic faculty salary. Such outside grants are strongly encouraged.

UNARC started in 1972 with physical and allied sciences, namely, chemistry (especially physical chemistry), physics (especially electronics and semiconductors), and mathematics and computer sciences. A few years later it added biology (especially molecular biology), and more recently, under pressure "to help Egypt," it set up a division of applied sciences with two main subjects of study: Environmental science, and science-industrial coordination. However, it remains committed to basic research.

The prestige of the Center is reflected by the competition in some faculties to obtain posts at UNARC. These appointments are given annually and are usually renewed, but frequently rotated. UNARC also has considerable support from "international experts." Expatriate Egyptians are especially desirable, but the Center has great difficulty paying such people—a large number of Egyptians hold professorial positions in the US—although AID sometimes helps. The Center hopes to be able to set up joint appointments for a period of five or more years, wherein a professor would be six months at a university in the United States and six months at UNARC.

When being introduced to the staff, I was surprised at how many of them are women. (I had not expected this in a largely Moslem country.) The women on the staff include the holder of the chair in the Molecular Biology Research area.

There is a group working on solar energy from photovoltaic silicon cells under the direction of M. Shabana, who got his doctorate in applied physics at Harvard in 1965 and is now a professor in the electrical engineering faculty at the Univ. of Alexandria. Together with three other PhDs, he is working on both crystalline and amorphous silicon photovoltaic cells. In the former area the group is being partly supported by the Univ. of Eindhoven, the Netherlands. I quoted to Shabana a statement by Dr. I.A. Sakr, Head of the Solar Energy Laboratory at the National Research Center, to the effect that electricity generation by solar energy was unlikely in Egypt in the foreseeable future. He felt more optimistic about the possibility that it might be used, particularly

in desert areas that would be difficult to reach by transmission lines. But he asserted that even if this were not true, it is essential for Egypt to have people working in the forefront of science, so that they can take advantage of developments in other countries.

Another group, under Professor Salah Morsi, is working on photovoltaic cells from III-V compounds such as gallium arsenide and indium phosphide. Morsi is also directing research by a Mohammed El-Morsi (no relation). The two are working on component problems (rather than on system problems) related to solar energy; for example, coating the cells to prevent their deterioration.

Among the other research projects going on at UNARC are extensive studies in corrosion (especially relevant to Alexandria, since this is a coastal city and the largest port in Egypt); multidisciplinary approaches to the study of polymers and colloids; laser work, primarily using CO_2 and HF lasers; studies on biochemical and molecular genetics; studies in cell biology and membrane biology; and even some comparatively pure mathematics including the theory of elasticity and plasticity and some work on functional analysis. In every one of these areas there has been publication in first-rate refereed scholarly journals, mostly in the English language.

I am willing to predict that while UNARC may not rival the Institute of Advanced Studies at Princeton for some time to come, we will hear more of this startling and thriving institution. (Robert E. Machol)

HIGH STRENGTH LOW ALLOY STEELS

An international conference entitled "High Strength Low Alloy Steels-Experiences in Applications" was convened 22-24 January 1979 in Versailles, France, organized jointly by La Société Francaise de Métallurgie and The Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers. This meeting was intended by the organizers to continue the international dialogue established at previous conferences such as the "Symposium on HSLA Steel" in Nuremberg in 1970, "Microalloying 75" in Washington DC in 1975, and "Welding of HSLA Steels" in Rome in 1976. The Versailles meeting attracted about 185 delegates, with a program of 24 papers from a dozen countries.

The conference presented recent research and experience reports on a variety of problems, such as hydrogen pipeline steels and weldments, stress-corrosion cracking, marine corrosion and corrosion protection systems, fatigue, fabrication, and heat treatment. In spite of the conference title, the papers presented were not qualitative experience reports but rather, for the most part, detailed research papers in the alloy development vein. If one wanted to be an aloof "pure scientist," he could probably look down his nose at this conference, but the technological significance of the subject is so great that the proceedings must be considered to be of significant value. The general tone of the papers was to present recent research results that help to advance understanding and solution of the problems prevailing in HSLA steel service situations. Thus, in the first two days the conference program was divided into four sessions on Hydrogen, Fatigue, Corrosion, and Fabrication and Heat Treatment. The third day was given over to a series of three round table discussions, on Dual Phase Steels, HSLA Steel Plates, and HSLA Steel Pipes.

In all of the first four program sessions, the two dominant topics were welding and sulfides. Welding is usually the critical fabrication step relative to hydrogen problems, fatigue, and corrosion, while sulfides are often the critical microstructural feature in these three areas. Welding, a source of hydrogen, gives rise to factors that diminish fatigue strength and creates microstructural heterogeneities that promote localized corrosion. Sulfides constitute possible sites for hydrogen accumulation, fatigue cracking, and preferential corrosion.

Before carrying on with a review of the proceedings, it probably would be useful for some readers to have a definition of HSLA steels and some other brief background information. HSLA steels may be roughly designated as those with yield strength above about 50,000 PSI (345 MPa), and many are much higher than this level. A great variety of low alloy steel compositions are able to achieve these values with appropriate processing; however, most HSLA steels have low carbon (around 0.1 to 0.2%),

and the phrase "low alloy" indicates that no alloying elements are present in more than a few percent proportion, many much less. The major alloying elements (those with highest percentages) are typically Ni, Cr, and Mo. In recent years, more and more HSLA steels have included careful composition limitations on certain deleterious elements, notably sulfur, and the use of microalloying has become very popular as a means of improving properties. HSLA steels are making rapid inroads in numerous important technological applications, including bridges, buildings, ships, pressure vessels, pipelines, and automotive. These applications, driven strongly by economic considerations, take advantage of several key aspects of HSLA steels, most notably higher yield strength, which allows reductions in section thickness and therefore weight for a given service stress, or allows greater service stresses for the same structural weight. Another aspect, perhaps not so widely appreciated, is that the manufacturer of a ton of HSLA steel consumes about the same energy as for a ton of conventional steel, so that on the basis of its desirable properties the HSLA steel is really more energy-effective, sometimes substantially so. The reader with an interest in further information on the topics emphasized in this note (welding and microstructural control in steels) is referred to related discussions in two recent *ESN* articles on European conferences on steel welding (*ESN* 33-3:93) and quantitative metallographic studies of steels (*ESN* 33-4:156).

Hydrogen problems of several types are prevalent in HSLA steels, and these were the subject of considerable discussion at the conference. One of the classic scenarios involves hydrogen blistering of mild steel in H_2S-containing environments, a problem in the oil industry for three decades. The continuing increase in oil and natural gas prices has made the utilization of "sour" gas reserves more and more economical. (Sour gas is defined by the National Association of Corrosion Engineers as natural gas with H_2S partial pressure greater than 0.0035 bar). In addition, "sweet" natural gas may in time turn sour owing to the action of bacteria carried by injected seawater. In natural (sour) gas transmission lines residual or condensed water pockets can become saturated with H_2S, forming sulfuric acid (H_2SO_4), and corrosive attack by this acidic solution produces atomic hydrogen on the surface that diffuses into steel, recombines to form molecular hydrogen (H_2) at pre-existing microvoids, and builds up internal pressure. Depending on the properties of the steel, this hydrogen entry can lead to hydrogen blistering or hydrogen-induced cracking ("hydrogen embrittlement").

The two basic solutions that have been attempted since the early 1950s have been the development of more compatible alloys and protection against damage to incompatible alloys. Of these, the first (materials) approach has been difficult, often resulting in more expensive materials such as Monel, nickel, and stainless steels, and the second (protection) approach is always subject to problems of reliability. To avoid or minimize hydrogen effects, the most common nonmetallurgical approaches are coating with corrosion inhibitors and H_2S extraction from the natural gas. However, recent accidents with oil and natural gas pipelines have given renewed impetus to the development of materials resistant to hydrogen blistering, and the most promising approach involves "microalloying," i.e., the addition of very small amounts of alloying elements to steel compositions. For example, at this conference, M. Iino and coworkers (Nippon Steel, Kanagawa, Japan) reported on the dramatic control of hydrogen entry into steel (from brine containing H_2S) that is achieved by microalloying with one of the following: 0.25% Cu, 0.05% Cr, 0.2% Ni, 0.01% Bi, 0.02% Rh, 0.1% Pd, or 0.1% Pt. Work on the H_2S-induced problem was also presented by G. Guntz and coworkers (Service de Recherches du Centre d'Etudes, Vallourec, France).

Other important factors influencing blistering tendency are the shape and distribution of non metallic inclusions on which hydrogen is precipitated to form the blisters. Elongated manganese sulfide (MnS) inclusions are the classic villain. Inclusion shape control can be achieved via the microalloying route; for example, Iino reported on the effect of 0.01% Ti in combination with rare earth metals (REM). It is speculated that the effect is caused by uniform dispersion of REM sulfide or oxy-sulfide inclusions by the action of titanium nitride acting as uniformly dispersed

nucleation sites. Thus the rare earth acts effectively as a "getter" for sulfur, thus suppressing growth of the manganese sulfide which would be elongated in the rolling process.

Another traditional hydrogen problem arises in connection with welding of HSLA, where hydrogen entry can lead to "delayed failure" [sometimes referred to as "hydrogen-induced cracking" (HIC)] in welds. Empirical alloy selection equations [e.g., "carbon equivalent" (CE) equations] have been developed and used to help select steels with less susceptibility to delayed cracking. However, discrepancies among various CE equations and the lack of input on the effect of varying welding procedures can easily result in the selection of the wrong alloy/welding process combination. One solution to this has been the development of more complete, but also empirical, predictor diagrams, as described by D.W. Dickenson (Republic Steel, Cleveland, OH). These are derived from the results of large numbers of hydrogen implant tests that simultaneously related hydrogen cracking susceptibility to steel composition and welding procedures.

Weldability (of pipeline steels) was discussed by B.L. Jones (British Gas Engineering Research Station, Killingworth, Newcastle upon Tyne, UK). Also L. Chaussy (Aktiengesellschaft der Dillinger Hüttenwerke, Dillingen, FRG) described recent investigations into the metallurgical possibilities of improving resistance to HIC for sour gas equipment. In experiments carried out by his company, microalloyed fine-grained steels at various strength levels were exposed to H_2S-saturated synthetic seawater at various pH levels. The influence of heat treatment, cold forming, applied stress, and welding were investigated for various inclusion contents and shapes. Investigations of a very similar nature were reported by C. Parrini and A. DeVito (Italsider SpA, Taranto, Italy), again considering alloying effects on HIC, with the effects in this case measured by means of standard sulfide stress corrosion and British Petroleum tests on base metal and welded joints. Also a new patented welding method to produce HIC-resistant joints was described.

On the subject of fatigue, the discussions centered on the fatigue resistance of welds. F. Bastenaire and coworkers (IRSID, St. Germain-en-Laye, France) reported on results of a joint research program sponsored by the European Community intended to arrive at realistic fatigue properties on welded assemblies. Welding was carried out in several different welding institutes and fatigue tests conducted in several laboratories. In spite of the number of variables (welder, machine, test method, etc.) the care taken in defining the welding techniques and test methods made it possible to obtain comparable values in different labs. With this standardization in hand, evaluations could then be made of the influence of factors such as steel type, yield strength, notches, type of welded assembly, weld quality, and service stress conditions.

It is well known that under conditions of constant amplitude loading, fatigue properties of as-welded joints are almost independent of mechanical strength characteristics of the base metal. Selecting an HS grade is worthwhile only in some particular cases: small number of cycles to failure (so-called "low-cycle fatigue"), high mean stress level (structures with high deadweight), or situations with risk of accidental overloads. Because of this common independence of weld fatigue properties, the obvious approach is to improve the weld quality, and several means are used to do this, including grinding, peening, surface remelting, etc. A paper by P. Simon and A. Bragard (Centre de Recherches Métallurgiques, Liège, Belgium) described the results of research carried out to assess fatigue improvements rendered by TIG remelting practice with microalloyed steels.

Discussions of the corrosion performance of HSLA steels were most concerned with the effects of weld heat-affected zones (HAZ). For certain applications, such as ship hulls, general corrosion resistance is a quality that must be obtained along with strength, toughness, weldability, and resistance to cracking. A report on the corrosion performance of special microalloyed shipbuilding steels, with restricted Mn, Si, and S was given by E. Räsänen and coworkers (Research Centre of Rautaruukki Oy, Raahensalo, Finland). The classical problem in this application is with welds that show HAZ and fusion line sensitivity to corrosion attack that is often associated with sulfides. This was also discussed in a paper by P. Drodten (Thyssen Henrichhütte,

Hattingen-R.F.A.), where actual North Sea exposures in various marine conditions were carried out. The deleterious effect of sulfur is most marked in the splash zone, less so in the tidal zone, and nil in full immersion, owing primarily to the differences in oxygen availability for the particular corrosion processes that involve the sulfur.

In another context, a paradoxical effect of sulfur on toughness was considered by N.E. Hannerz (Svenskt Stal AB, Oxelosund, Sweden). The paradox refers to the fact that depending on the test used to measure toughness, sulfur has either a detrimental or a favorable effect. In standard Charpy-V notch impact tests, sulfur depresses the energy absorption level of the material at the so-called "upper shelf" (plateau in a sort of lazy S-shaped plot of energy vs temperature) and raises the ductile to brittle transition temperature (inflection point in the lazy-S-shaped plot), i.e., is detrimental. However, if the transition temperature is obtained from the standard Battelle drop weight tear test (BDWTT), the trend is just the opposite. This paradox has been observed by various workers for a range of steels of different strength levels. The metallurgical bases for this paradox were discussed in terms of microstructural features (particularly sulfides) and their effect on deformation behavior in the different tests.

In the session on fabrication, two presentations from French steel research centers, by G. Bernard et al. (IRSID, St. Germain-en-Laye, France) and R. Blondeau et al. (Creusot-Loire, Creusot, France), considered possible pressure vessel and boiler applications and related codes for HSLA steels. Existing codes that emphasize tensile strength over yield strength do not especially favor the selection of HSLA steels by designers. However, certain superior features of HSLA steels such as weldability, and excellent transverse properties owing to desulfurizing, microalloying, or sulfide shape control would be most useful. The IRSID group presented the results of studies intended to provide missing information on several critical properties for pressure vessel applications, such as response to fabrication and service conditions, including straining and aging, stress relief treatments, stress relaxation, creep, etc. For example, pressure vessel codes generally impose a requirement for stress relief after welding, with the aim of relaxing welding-induced stresses. The Creusot-Loire presentation concentrated on the response of HSLA steels to various stress relief treatments, and several accompanying deleterious effects have been noticed, including embrittlement caused by precipitation or segregation, reheat cracking, and hydrogen induced cracking. Also, P. Charpentier and H. Piehler (Carnegie-Mellon University, Pittsburgh, PA) contributed a paper assessing the effect of cold forming of HSLA sheet, with special attention to attendant ductility losses and anisotropy development.

Naturally there is great interest both in the data acquired by studying the various problems of HSLA steels and in the mechanisms of these effects. The latter are, of course, more elusive, and considerably more research is required to understand fully the role of microalloying elements and the interaction with processing variables. This conference presented only a small cross section of the current activity in the field, for this was a far less comprehensive program than the outstanding "Microalloying 75" meeting. But it is evident that progress in the direction of fundamental understanding is considered secondary by many workers. This is probably because, to a large extent, the necessity of dealing with complex materials and processing histories do not favor the delineation of basic mechanisms. At the same time, simply by virtue of the amount of work being done, there are quite substantial improvements in properties being realized, and these are very valuable from a technological standpoint. (Jeff Perkins)

MEDICINE

PREOPERATIVE HYPOTHERMIC RENAL PERFUSION: ANOTHER USE FOR THE ARTERIAL CATHETER

Radiographic visualization of any portion of the arterial system is a well-recognized and time-honored diagnostic procedure. More recently an increasingly wide variety of therapeutic uses for the arterial catheter have also been described. For those unfamiliar with the procedure a brief historical review of therapeutic arteriography follows.

One of the earliest and best known of these procedures is single organ perfusion in cases of advanced cancer. After visualization of the malignant lesion in an organ (the liver would be a good example), the arterial catheter is left in place for continuous infusion of chemotherapeutic agents. By this method the entire organ can be perfused with a much higher dose of the cancer killing drug than one could otherwise use. Likewise, but for diagnostic purposes, an infusion of epinepherine (adrenaline) is commonly employed to identify abnormal neoplastic vessels in renal carcinomas, as normal vessels will constrict. The arterial catheter is also useful in non-neoplastic disease. For example, gastrointestinal hemorrhage can often be controlled by infusion of a vasopressor agent after the bleeding site has been identified by arteriography. Many neoplasms are quite vascular, which considerably increases morbidity and mortality as well as the technical difficulty in carrying out the necessary surgery. The introduction of autologous blood clot or foreign material through the arterial catheter into the artery feeding a cancerous organ greatly reduces the vascular supply and provides much simpler and less hazardous surgery. This technique has been employed most commonly for carcinomas of the kidney. Introduction of a clot into the renal artery, however, can only be carried out if the kidney is to be sacrificed at surgery, which is virtually always the case if a neoplasm is present.

The kidney, because its blood is most often supplied by a single accessible artery, has been the target of continued investigation. In order to provide a relatively blood-free operative field in non-neoplastic surgical procedures, investigators have sought ways to reduce renal blood flow while not injuring the kidney. Kidney surgery for removal of calculi can often be technically difficult, particularly if the stones are multiple and the kidney scarred from previous infection. A temporary reduction in the blood supply during the surgery would, therefore, clearly be of considerable advantage.

Dr. Max Georgi, the recently appointed Professor of Radiology and Director of the Department of Radiology at the Univ. of Heidelberg in Mannheim, was previously involved in arterial catheter research at the Univ. of Mainz with Dr. M. Marberger and others. One of their projects was an attempt to reduce renal arterial blood flow during surgery for renal calculi. The essence of the procedure is to occlude temporarily the renal artery and provide a "bloodless field" but still prevent tissue death due to ischemia. To accomplish this local renal hypothermia is necessary. Marberger, Georgi, and their coworkers developed a simultaneous balloon occlusion of the renal artery with hypothermic perfusion which they reported in the *Journal of Urology* late in 1978.

The procedure is essentially simple and not time consuming. To prevent vasospasm the patient is pre-treated with oral dibenzyline for four days before the surgery. On the day prior to surgery an aortogram is carried out to visualize the renal arteries and to insure that there is a single vessel supplying each kidney. The catheter is left in the aorta and on the day of surgery it is placed under fluoroscopic guidance in the orifice of the renal artery. The usual catheter employed in this procedure is a double lumen Swan-Ganz, five french in size. The catheter is positioned 2 cm proximal to the origin of the most proximal renal branch artery. The balloon is then filled with saline to occlude the artery. (This requires 0.2 to 0.6 of a ml.) The technique is not and should not be used with arteries less than 4 ml in size. A test injection of contrast material is carried out to insure that the balloon has completely occluded the renal artery. The balloon is then deflated and the patient taken to the operating room.

After the kidney is surgically exposed the balloon in the renal artery is re-inflated to the same size (using exactly the same amount of saline) and the kidney perfused with a hypothermic solution of Ringer's lactate cooled to 4° to 6°C. A flow rate of 50 ml/min. is used. Renal core temperature is monitored and it has been determined that approximately 500 ml of hypothermic lactate will lower the renal core temperature to approximately 18° to 20°C. Surgery then can be commenced and the renal core temperature is continuously monitored. When renal core temperature rises to 25°C perfusion is re-started, the temperature reduced, and surgery continued. The total hypothermic solution perfused approximates 1500 ml/hr, and the mean ischemia time of the procedure is 54 minutes.

Thirty-one cases were operated upon using hypothermic perfusion. These cases were not simple single pyelolithotomies but of the complicated variety that necessitated in most instances removal of multiple calculi from the kidney. Of the 31 cases, 26 were considered successful. In four of the unsuccessful cases, the catheter inadvertently came out of the renal artery during the procedure. In one case the balloon burst in the renal artery because it had become lodged in a small aneurysm and inadvertently over inflated. This caused thrombosis of the renal artery and necessitated the removal of the kidney.

In the postoperative phase the recovery of the kidney from the surgery as well as from the hypothermic perfusion is monitored by ^{131}I-hippuran clearance studies.

When we toured his Department in Mannheim, Georgi showed me the rooms in which procedures are carried out. The modern equipment, the general orderliness and cleanliness of the rooms, as well as their immense size were very impressive. Radiographic rooms in Mainz, Frankfurt, and Mannheim were all considerably larger than the average radiographic room in the UK or the US. It is obvious that German radiologic installations have clearly benefited from a strong economy.

Hypothermic perfusion of a kidney during surgery has allowed for temporary renal arterial occlusion and has simplified surgery for complicated nephrolithiasis. The procedure is an ingenious natural outgrowth of the many uses for the arterial catheter in therapy as well as diagnosis. (Irwin M. Freundlich)

OCEAN SCIENCES

SOME NOTES ON REMOTE EM SENSING OF THE SEA SURFACE

The UK Institution of Electrical Engineers held a one-day Colloquium on "The Sea Surface—Target or Clutter" in London on 12 February 1979. This article covers part of the session on Electromagnetic Sensing of Sea Surface Conditions.

Dr. D.H. Webb (British Institute of Oceanographic Sciences, Wormley) reported on a comparison of ocean wave heights as measured by the radar altimeter on the SEASAT satellite and those measured by a pitch-and-roll buoy.

The SEASAT used a chirped radar pulse. The return signal was correlated with a replica of the transmitted pulse, with the result that time delay became mapped into a frequency offset, and so range gating could be replaced by frequency filtering. This technique allowed a 3.2-μsec pulse to give 3 nsec resolution and an altitude precision of better than 10 cm.

The roughness of the sea surface owing to waves causes a distortion of the leading edge of the radar pulse return. A simple algorithm was used on the satellite to compute a measure of significant wave height data, which was then transmitted along with the altimeter pulse delay and the leading edge wave form. In the UK these data were received by the Royal Aircraft Establishment of Oakhanger.

Because of SEASAT's potential usefulness in obtaining wave height data over oceans where even rudimentary data is at present rarely available, it was desirable to compare SEASAT data with ground truth whenever possible.

Ground truth was obtained during JASIN-1978 (British Royal Society Joint Air-Sea Interaction Experiment), which took place in the Rockall Trough northwest of Scotland near 59°N, 12°20'W from July to September 1978. Wave heights were recorded there at times coinciding with SEASAT passes overhead. Measurements were made with a pitch-roll buoy, usually for four-hour periods. An hour of good data taken as near as possible to the time of the satellite pass was used to make the comparison.

The pitch-roll buoy measures the vertical accelerations at half second intervals. This was integrated to give the rms amplitude of the surface. The rms amplitude was multiplied by four to give a normal significant wave height (average height of the highest 1/3 of the waves).

Successful comparisons were made on several occasions. These occurred during periods of low seas when the significant wave height ranged between 70 cm and 2 m.

Five of the comparisons were self consistent, in the sense that the SEASAT altimeter overestimated the wave height by 50 cm. There was an rms error of 20 cm. The other two comparisons were inconsistent. Webb believes that this inconsistency was caused by the faulty

operation of one of the set of three sampling gates used to estimate the wave height. During two "wild" passes, another set of gates was used for two short intervals during which the data were consistent with the five "good" comparisons. The algorithm for significant wave heights used on SEASAT was a tentative one, and it was expected that experience would show how it could be improved. The 50-cm linear offset seen by the satellite could have been caused by noise in the satellite receiver. The 20-cm rms noise could have been caused in part by the separation between the regions sampled by the satellite and by the pitch-roll buoy.

The SEASAT altimeter appears to be about an order of magnitude better than its predecessors in resolving wave heights and should become a very useful instrument on future SEASAT satellites.

Drs. A.D. Heathershaw, P.J. Hardcastle, and M.W.L. Blackley (Tauton Laboratory, UK Institute of Oceanographic Sciences) discussed the use of conventional x-band, high resolution, scanning shore-based radar for local wave resolution. It was shown that relatively cheap and simple radar can be used to study wave direction and wave refraction (the changes in wave direction and focusing and defocusing of wave energy due to uneven bottom topography), diffraction (bending of waves around ends of breakwaters or other obstacles), and reflection from the shoreline in the vicinity of harbors and on open coastlines. Each of these three processes modifies the amount of wave energy that will be found in a harbor at any particular place or time or at any location along a shore line.

The visual presentation by the radar shows each sea or swell wave crest in the wave field within the field of view of the radar. The radar gives a nice picture of the refraction and diffraction on reflection if sufficient energy is reflected to show observable wave trains.

A generation ago I made a living by very laboriously hand computing and drawing refraction diagrams for harbor approaches and harbors in southern California. To obtain a complete picture at any given location, diagrams had to be drawn for a range of wave periods and a range of different directions of approach. It was indeed a revelation to see instantaneous wholly accurate "natural" refraction diagrams that had been generated by the radar.

The direction in which the waves are moving can be calculated to within ±5° with simple radar sets and to within ±2° under the best conditions with more sophisticated sets. Wave direction can be detected with a range of 2 km. Wave refraction can be displayed for a range of 4 km.

The wave amplitude has to exceed 1/2 in order to be "seen" by the radar. The radar misses the swell if the wind is below the threshold value of 4 or 5 m/sec that is necessary to roughen the sea surface with small wavelets. However, the wind need not be in the direction that swell is moving in order to make the swell visible to the radar. Unfortunately little information is given on wave height except that it is over the threshold value. A pressure wave recorder on the bottom has to be used to determine height, while the other wave characteristics are determined by radar.

It has been found through experience that the best height for the radar antenna is in the range of 15 to 20 m above mean sea level.

Dr. Birger Ekengren (L.M. Ericsson Telephone Co., Mölndal, Sweden) presented a paper on maritime surveillance by real aperture side looking airborne radar (SLAR). The radar system was developed and tested for the Swedish Coast Guard for the purpose of monitoring oil spills at sea.

An inexpensive x-band radar with a relatively long fixed antenna is mounted under the wing or fuselage of a small airplane. The antenna beam is pointed perpendicular to the flight path. The aircraft motion is used to establish the search pattern. The effectively large antenna gives very good resolution, and the typical time on individual target is increased from the 50 msec for small-antenna forward-looking airborne radar to 1 sec or more. This long time on target reduces the effects of sea clutter and produces better mean reflectivity.

The objective of test flights with Ericsson SLAR has been to evaluate the capability to detect oil on water. The results were very encouraging. Spills as small as 400 liter could

readily be detected. The contrast between oil and water has been found to vary little with the angle of incidence or with wind direction and is usually of the order of 5 to 10 dB. Under favorable conditions the contrast between sea ice and water is also very good, and the distribution of sea ice can also be mapped with SLAR.

The uniform sea background and high area resolution make it possible to detect targets with radar cross sections of only 1 m^2 within 20 km of the aircraft, making SLAR an excellent tool for search and rescue missions. Ships can be detected out to the maximum range of the radar used.

In addition to the remote EM sensing that was reported on in this IEE Colloquium, there is similar work under way at the Bidston Laboratory of the Institute of Oceanographic Sciences (IOS). This is the center of tidal research in the UK and originated from the Liverpool Tidal Institute. Dr. David Cartwright, head of the Laboratory, and his assistants are making an oceanographic contribution to SEASAT altimetry. They are calculating the deformation of the sea surface caused by tides and weather for selected areas, using purely oceanographic models for all available satellite passes. They are conferring with geodesists for exchange of geodetic, orbital, and altimetric data and are testing for significant reductions of residual variance when oceanographic data is added to the altimetric equation. If the above proves to be successful, they plan to use the data in other oceanographic areas for determination of tides where they are little known.

The North Sea and the English Channel are being used as primary areas of calibration because the geodesy and oceanography of these areas are supposedly well known and the surrounding land areas are covered with a dense network of laser and Doppler tracking stations. Cartwright and associates are computing the anomalies due to the dynamic effects of atmospheric pressure and wind stress which have long been studied with the IOS continental shelf model. These computed anomalies will then be compared to residuals in sea surface height during satellite passes. Other sources of anomalies will be taken into account, such as the "body tide" and the "loading tide" of the earth for the semidiurnal tidal components of the moon (M_2) and sun (S_2).

It is planned to extend these studies to the Northeastern Atlantic Ocean and the tropical Atlantic Ocean.

The topics touched on above are just a small sample of the work on electromagnetic sensing in progress in Europe, and in particular in the UK. Much work in this topic has, of course, been in progress in the US for a number of years. (Wayne V. Burt)

PHYSICAL OCEANOGRAPHY AT NIOZ

One of the largest, most elegant and delightful marine laboratories in the world is the Nederlands Instituut voor Onderzoek der Zee (NIOZ), the Netherlands Institute for Marine Research. It is located on the beautiful pastoral island of Texel, off the northwest coast of the Netherlands. The $16 million building with over two acres of floor space was completed in 1977. It is surrounded on the landward side by green fields, low hedges and drainage canals.

The long, low laboratory building blends into its grassy green background. It is nestled between two dykes in such a way as to be hardly noticeable from a distance. The laboratory was originally designed as a high tower but the citizens of the island, very much concerned with protecting their environment, were able to prevent its construction. The architect simply lifted off the floors of the tower and placed them on the ground, connecting them with a long corridor, like beads on a string. The result is a rambling building with many angular side corridors where even the directors admit to getting lost. The interior is decorated with a beautiful combination of lots of natural wood trim, large red bricks and multi-colored walls.

The Institute is managed by two co-directors. Dr. H. Postma, a well-known chemical oceanographer, director of the physical, chemical, and geological oceanography groups, and Dr. J.J. Zijlstra, a fisheries researcher, head of the marine biology and pollution groups. The Institute is part of the Dutch Zoological Society, but obtains most of its funding directly from the Netherlands Government.

By charter, NIOZ is the center for basic marine research in the Nether-

lands. Since the country is very much oriented toward the oceans and has many different organizations carrying out applied research in various aspects of marine science and technology, however, NIOZ also does a good deal of applied research, particularly on problems associated with fisheries.

The Institute's efforts are about equally divided among research in the open ocean, in the North Sea, and work in the Wadden Zee off the north coast of the country. Texel is one of the barrier islands that enclose the Wadden Zee.

NIOZ has its own new well-equipped 32-m 250 ton vessel AURELIA for use in the North Sea and the Wadden Zee. For deep ocean work NIOZ workers use 6000-ton chartered vessels or the big new research vessel TYDEMAN belonging to the Navy. They use about 15% of the TYDEMAN's ship time.

There are 30 senior scientific research personnel divided into eight groups: physical oceanography, chemical oceanography, marine geology, pollution research, and four marine biology groups (pelagic, benthic, autecology and experimental biology). There are 90 support personnel and an average of 20 graduate students. Students can come from all eight Dutch universities. Unless they are doing doctoral research, the usual stay is six months.

All of the laboratory directors whom I have met on the Continent take great pride in the fact that they also hold professorships in universities. In some cases this requires a lot of effort. prime example is Postma, who drives over 200 miles round trip to teach his classes in Groningen University.

There is a five-man group working in physical oceanography, with plans to double the number in the near future. The senior man, Dr. J.T.F. Zimmerman, has been working at the Institute for seven years studying mixing and diffusion and heat budgets. He is a prolific writer with a good theoretical background in physics who makes extensive use of field data. He has published most of his papers in the *Netherlands Journal of Sea Research*, which is devoted mostly to marine biological subjects and, unfortunately, is not normally perused by physical oceanographers in the United States.

Zimmerman has spent much of his time studying mixing and flushing in the Wadden Zee. This body of water is loosely separated from the North Sea by the West Frisian Island arc. Its principal economic importance is that its shallow waters form the nursery ground for immature stages of some commercially important species of fish that are caught in the North Sea. Mixing and flushing rates and processes are biologically important because they control: (1) the salinity distribution within the sea, (2) the movement and distribution of nutrients and phytoplankton, and (3) the dispersion of pollutants.

One of the most influential pollutants in the Wadden Zee is the high turbidity of the shallow tidal waters, as it severely limits the penetration of sunlight necessary for primary production. A major source of turbidity that is under study is the stirring up of bottom sediments during the process of mining for sand. Several million cubic meters are recovered from the bottom of the Wadden Zee each year and are used to raise the ground level in the polders for the foundations of building sites and for the roads. This is because in order to build a highway, a canal must be dug along the route and up to 10 m of soft, peaty soil has to be removed. The canal is then filled in with sand and the highway is built.

Salinity is normally used as a natural tracer in estuarine mixing and diffusion studies. Zimmerman is fortunate in having a second semi-conservative natural tracer to use in his studies. This is the terrestrially derived natural fluorescence in Rhine River water. About three-fourths of the Rhine with its high natural fluorescence flows up the coast of the Netherlands from the mouth of the Rhine. A part of it is tidally mixed into the Wadden Zee. A second smaller source of Rhine water, averaging $2 \times 10^7/m^3$ per tidal cycle is discharged into the Wadden Zee through the sluices in the dyke that separate the Ijesselmeer from the Wadden Zee. This Rhine water has lost half its natural fluorescence as it slowly passed through the IJesselmeer. Knowing the fluorescence of each source of Rhine water and the salinity and fluorescence of any water sample in the Wadden Zee, Zimmerman can compute the percentage of water from each source in the study of the mixing processes within the Wadden Zee.

Zimmerman has developed a model for dispersion mixing in the Wadden Zee that employs tidal-induced residual current vortices; the model should be applicable to other uneven bottomed estuaries. He has shown that irregular bottom topography acts as a catalyst for transferring vorticity from the oscillatory tidal velocity field to the mean residual field. He is planning a joint field experiment with Dr. A. Okubo and his coworkers at State Univ. of New York at Stony Brook to test and improve his model. He is also developing a new model for determining characteristics of mixing from differences in statistics of concurrent Eulerian and Lagrangian current measurements.

Zimmerman's second research project is concerned with the heat budgets of tidal flats. Temperature is one of the most important physical factors in the ecosystems of tidal flats. Moreover, in planning power stations that will discharge heated effluents in areas of tidal flats, the special characteristics of heat balance in these regions should be taken into account.

Zimmerman and H. F. Vugts (Free University of Amsterdam) have shown theoretically that in a sea area consisting partly of periodically drying tidal flats, the semi-diurnal lunar tide, interacting with the daily variation of solar radiation, gives rise to a beat in the amplitude of the daily water temperature cycle with a period of 14.76 days and a variation of the daily mean temperature within the same period. They have made the first systematic survey of temperature in a tidal flat area extending over six 15-day periods of time. The survey, made on Mok Bay on Texel, confirmed the 14.76-day beat frequency that had been postulated by the theoretical study.

Dr. D. Spitzer and his assistant M.R. Wernard comprise the two-year old two-man marine optics group. This group was established at the Institute to help fill the needs of the marine biologists who wanted detailed information on the distribution of solar radiant energy in the sea that can be utilized by plants for photosynthesis.

Marine optics has suffered from a plethora of different instruments and techniques for measuring light in the sea. Many of these instruments have been prototypes, and the data taken by individual researchers are difficult to compare. Working Group 15 of the Scientific Committee for Oceanographic Research (SCORE) of UNESCO has concerned itself with this problem and has recommended a practical standard detector for photosynthetically useful radiant energy in the sea. The recommended photon scalar irradiance meter should measure the light equally from all directions in terms of quanta within the range of 350 and 700 nm. Several experimental prototypes have been built, but none are available commercially.

Spitzer and Wernard have designed and built an instrument based in part on a sensing technique that is new to marine science and gives a super linear response over the desired part of the light spectra [*Applied Optics* 17,12 (1978) and *Applied Optics* (1979) in press]. The completed instrument has been used operationally on two cruises in the Atlantic.

Two hemispherical opal-glass spheres are interlinked across an integrating sphere. The water-filled spheres are blacked over one half of their surface so that only their outer halves can collect radiation. A collimating lens images an aperture in the wall of the integrating sphere onto a quartz cell containing a fluorescent solution of rhodamine B dye. The detection in the required 350-nm to 700-nm visible radiation region is then covered (a) by detection of the emitted radiation excited with constant quantum yield in rhodamine B by the incident radiation between 350 nm and 600 nm, and (b) by detection of the incident radiation reflected by the surface of the cell between 600 nm and 700 nm, where the detector has approximately constant quantum response. The radiation in each of the above bands is detected by a PIN silicon photodiode. The recommendations of SCORE WG 15 have been met, and with the new instrument, data can be obtained routinely at sea.

The Institute is carrying out a series of blue ocean primary productivity studies in a westward direction along the 20°N latitude parallel from the edge of the coastal upwelling region off NW Africa to the more desert region further at sea. During a recent cruise studies were made of the spectral distribution of solar radiation as it changes with depth and distance from shore. This was part of a study of the chromatic adaptation of phytoplankton to changes in the spectrum of the light available for photosynthesis.

Spitzer hopes to continue these studies in the future. He has also constructed a spectral irradiance meter. With this instrument he can determine the scalar and vector irradiance at eleven different bands in the visible spectrum. The complete instrument is unusually small, lightweight, inexspensive, and accurate. With it, he obtained data to compute the true absorption coefficient due to suspended and dissolved colored matter in sea water. His group has done an unusual amount of development work in a relatively short period of time.

The third program in physical oceanography is the study of small scale turbulence in the North Sea and in the tidal channels of the Wadden Zee. This study, which is mainly experimental, is carried out by C. Veth, who had his university training in experimental astrophysics at the observatory of Utrecht, and by his assistant M.W. Manuels. In the North Sea the subject of study is the structure and evolution of the seasonal thermocline in the stratified part of the Central North and the frontal zone between the stratified and unstratified region. In the tidal channels of the Wadden Zee the subject of interest is the relation between the velocity profile and the turbulence, and the way tidal energy is dissipated by bottom friction, etc.

A central tool in these studies will be the laser-Doppler velocimeter. This instrument is well-known in the study of laboratory flows such as in flow tanks, wind tunnels, etc., but has not been frequently used in the sea, although the method has some very useful properties in its fast response to velocity changes, calibration only determined by the geometrics of light beams, a very small measuring volume, and, in principle, no influence of the measuring system on the flow.

In this instrument a laser beam is split into two beams, one of which impinges directly on a photocell, while the other impinges on the flow. Light scattered by the volume of intersection of the second beam and the flow also strikes the photocell. Since the frequency of the scattered light is Doppler-shifted, the interference of the two light beams on the photocell area results in an electric current or voltage at the beat frequency, with this frequency proportional to the velocity component in the plane of the original light beams. The sign of the velocity component can be determined by giving a preshift to one of the beams. A frequency tracker is used to change the beat frequency into a voltage proportional to the velocity component. With the instrument now under construction it will be possible to measure two velocity components simultaneously.

The whole instrument is placed in a catamaran-type hull. The light beams go from one cylinder to the other, and the velocity components that can be measured are in the direction of the mean flow and the vertical velocity. Laboratory experiments show that turbulence spectra with frequencies up to about 2 kHz can be measured. The lowest detectable velocity was 0.2 mm/sec, and the dimensions of the measuring volume are such that studies on scales below the Kolmogorov scales are possible. Tests with models in flowtanks did not show influence of the system on its surroundings; however, tests are still going on. The first field experiments will take place in June 1979.

The Institute has extra space to grow into. It has its own small harbor and ship handling facility within walking distance of the laboratory building. It also has a very large closed circulation sea water system, located in its own building. A number of rooms are equipped with climate control systems, so that different climates can be simulated over aquaria or simulated tidal flats. The effects of different climates on the growth rates of various marine plants and animals are under study.

It was a very pleasant to visit this well-equipped and managed institute. (Wayne V. Burt)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

OPTOELECTRONICS

SEMICONDUCTOR INJECTION LASERS

Recent advances in the understanding, output characteristics, and utilization of semiconductor injection lasers were presented at a two-day conference at the University of Wales Institute of Science and Technology, Cardiff. This conference was jointly sponsored by the Quantum Electronics Group of The Institute of Physics, The Institution of Electrical Engineers and The Institution of Electronic and Radio Engineers. Scientists from most European countries were found among both the speakers and the audience. In addition to presentations covering crystal growth techniques and the fabrication and characterization of injection lasers, a number of papers on the theory and applications were presented. Highlights of some of the more interesting papers follow.

Semiconductor laser/optical fiber data (including voice) transmission is going to be used in a variety of high bandwidth applications. Because the attenuation and material dispersion of silica-based fibers are small in the 1.1μm to 1.3μm band, there has been considerable theoretical and experimental effort on semiconductor lasers emitting in this portion of the spectrum. In particular, work on GaAsSb/GaAlAsSb and GaInAsP/InP lasers was reported on at Cardiff.

An accurate determination of the refractive indices of the layers constituting both active and passive optical waveguiding components is important for several reasons. The refractive index is one of the parameters contained in the equations describing wave propagation in the waveguiding component, be it a semiconductor laser or an optical fiber. Also, the degree of confinement of the optical wave in such components is determined by the refractive indices of the guiding and adjacent layers, and the optical confinement in semiconductor lasers is one of the key parameters determining the threshold for laser action. Other important characteristics of semiconductor lasers such as the allowed longitudinal modes and the Fabry-Perot mode spacing are expressed in terms of the refractive indices.

M.J. Adams (Dept. of Electronics, Univ. of Southampton) presented the results of a study of different techniques for estimating refractive indices of quaternary materials such as InGaAsP. This study was motivated by both the necessity of knowing the refractive indices and understanding the origin of the discrepancies in their values as determined experimentally in different laboratories. The simplest (and unfortunately the least reliable) means of estimating the refractive index of quaternary materials involves a linear interpolation between the indices of the four binary components of a given quaternary. Recent far-field pattern measurements of an InGaAsP double heterostructure laser emitting at 1.15 μm have indicated a refractive index step less than half that predicted by linear interpolation. The effective-gap approach and the single oscillator model are alternative methods for estimating the refractive index of quaternary materials. Both of these techniques have been used with some success, and Adams feels that the single-oscillator model will provide the best refractive index estimates.

The thermal properties of semiconductor lasers and the interpretation of thermal resistance data are under investigation at the Post Office Research Centre (Martlesham Heath, Ipswitch). Simon Ritchie reported on inconsistencies between experimental observations on stripe geometry double heterojunction lasers and conventional models of junction heating. Specifically, the onset of thermal runaway in the cw threshold current occurred at temperatures much lower than that predicted theoretically. Also, lasers were found to fail because of thermal runaway in times considerably shorter than would be expected from the rate of increase in pulsed threshold. Conventional models express the pulsed threshold current, I_{TP}, in exponential form, i.e., $I_{TP} = A\exp(T_h/T_o)$, where T_h is the heat sink temperature and A and T_o are constants. Richie has observed a departure from this exponential dependence at high values of T_h, and he feels that this explains in part the model/observation inconsistencies. Also, his group observed that the temperature rise of the active region is not directly proportional to the input power. This nonlinear rise in temperature with input power can be accounted for if

multiple heat sources are considered, e.g., substrate absorption of spontaneous emission, nonradiative recombination in the active layer, ohmic heating, and absorption of spontaneous emission in layers adjacent to the active layer. A model incorporating multiple heat sources has been developed and will be published in the special issue of *IEE Journal on Solid State and Electron Devices* covering this conference.

Epitaxial crystal growth is a technique of producing single crystals by contacting an appropriate single crystal substrate with material either in the liquid or gas phase. The lattice constant of the substrate must be close to that of the new crystal, and the new crystal will grow with the same orientation as that of the substrate. Growth from the liquid phase, known as liquid phase epitaxy (LPE), is the most commonly used and best-developed technique for growing semiconductor laser crystals. Current research on chemical vapor deposition (CVD) growth of laser crystals is motivated partially by the possibility of improvements in uniformity and reproducibility. These improvements along with CVD's capability for large area defect free growth and its potential for large scale automation may someday lead to the preference of CVD over LPE. Standard Telecommunication Laboratories (STL) Ltd. has a 30-man semiconductor laser effort (See *ESN* 33-3:92), and E.J. Thrush of STL presented recent results on the preparation and characterization of GaAlAs/GaAs lasers grown by the metalorganic CVD process. Table I presents the characteristics of double heterostructure lasers that were grown by the pyrolysis of appropriate gas phase mixtures of trimethylgallium, trimethylaluminum and arsine between 720°C and 820°C in an RF heated reactor. Taking into account the short period of time of STL's CVD laser R&D effort and the comparability of the characteristics found in Table I with those of LPE lasers, the author feels that STL has made significant and rapid progress in this field. [The following recent reference contains considerable detail on metalorganic CVD: Russell D. Dupuis and P. Daniel Dapkus, "Preparation and Properties of $Ga_{1-x}Al_xAs$-GaAs Heterostructure Lasers Grown by Metalorganic Chemical Vapor Deposition," *IEEE J. of Quant. Elect. QE-15*, 128 (1979).]

TABLE I

Laser Wavelength	868 nm
Cavity Length	500 m
Cavity Width	24 m
Active Layer Thickness	0.2 m
Threshold Current	728 A/cm (best) 846 A/cm (mean)
Far Field Pattern	52° to 1/2 intensity
Nonradiative Lifetime	20 nsec
Carrier Lifetime	~ 3 nsec
Interface Recombination Velocity	$\leq$ 500 cm/sec
Yield	> 90%

Lasers are commonly used as a means of excitation for other lasers; however, laser processing of another laser is quite rare. R.P. Salathé (Institute of Applied Physics, University of Berne, Switzerland) reported on stripe geometry contacts produced on double heterostructure injection lasers by laser alloying. The ohmic contacts were formed by focusing the output of a Q-switched Nd:YAG laser with a cylindrical lens on the p-contact. This p-contact consisted of a 500nm-thick Zn-Au layer evaporated directly on the $Al_{0.36}Ga_{0.64}As$ cladding layer. Laser power densities between 100 and 300 MW/cm^2 were employed, and a 1 μm gold layer was electroplated on both sides of the sample after alloying. Stripe widths between 8 and 15 μm were realized with gold, and widths as narrow as 3 μm were made using aluminum. Of the diodes tested, several showed single mode operation, and cw operation at room temperature was achieved. The following advantages of contacts produced by laser alloying were enumerated by Salathé: short processing time (30 nsec); no protecting gas required; high spatial resolution; and no photolithography needed.

Currently, ITT Components Group Europe at Paignton, Devon is the only commercial supplier of laser diodes in the UK. With the pace at which progress is occurring, the author feels that at least one more commercial source will develop within the next two years.

Additional information on the above topics and semiconductor injection lasers in general will be available late this year in a special issue of *IEE Journal on Solid State and Electron Devices* covering this conference. (Richard S. Hughes)

PSYCHOLOGICAL SCIENCES

NATO SYMPOSIUM ON COPING AND HEALTH

A Symposium on Coping and Health, sponsored by NATO, was held during the week 26-30 March 1979 at the Bellagio Study and Conference Center of the Rockefeller Foundation in Italy. The setting was the beautiful Villa Serbelloni overlooking Lake Como, where the Foundation hosts small working conferences and short-term resident scholars. Dr. Neville Moray, the NATO Human Factors Committee observer, was among the 20 participants. Those attending included psychologists, psychiatrists, behavioral scientists, and endocrinologists from West Germany, Ireland, Turkey, Sweden, Norway, England, France, the US, and the Netherlands.

The Symposium was opened by Prof. Neal Miller (Rockefeller Univ., New York), a leading authority in psychology today. He presented a scholarly review of stress and the stress response, and coping in health and disease. Miller emphasized that the study of these subjects formed part of the developing field of behavioral medicine, an area receiving increasing attention with the formation of the *Journal of Behavioral Medicine* and the Academy of Behavioral Medicine. Investigators in these topics deal with the brain and the neurohumoral mechanisms it controls and they cover areas of perceptions, emotions, and drives along with consequent metabolic processes.

Miller first reviewed the involvement of the endocrine system in the body's response to stress from the Selye concept of "Alarm Reaction, Exhaustion, Adaptation" involving the pituitary-adrenal negative feedback system, and Cannon's adrenal medulla-epinephrine "fright, flight" system, to more current information that high doses of epinephrine cause platelet aggregation which may block blood vessels in times of stress, or mobilize free fatty acids, which if not burned up by adequate exercise, can result in increased synthesis of low density lipoproteins that may lead to atherosclerosis. He underlined the need to investigate the effects of chronic psychological stress and the rebound phase after a stressful situation, and then considered the epidemiological and clinical evidence of the effects of stress.

There is no evidence that one specific type of stressful situation leads to one particular type of stress consequence. Psychoses, suicides, accidents, susceptibility to disease, high blood pressure, diabetes, ulcers, are possible manifestations. Attempts to classify types of individuals that would be more likely to respond in one or another fashion, as in the Type A and Type B personalities, and their tendency to develop cardiovascular disease are biased in that other factors were not considered. Miller pointed out that there are many highly stressed people who do not develop cardiovascular disease and may simply be inherently tougher, just as some have a tendency to sprain their ankles while others do not. Stress and the stress response are not a simple cause and effect relationship. There is a balance between psychological factors and the physiological condition or response. He supported Ursin's definition of Stress as Increased Activation, while Coping is Decreased Activation. Thus, coping is anything that reduces the consequences of a stress response. For example, heart patients who deny the severity of their condition (emotional blunting) apparently have a better chance of survival. Pavlov had shown in his dogs that they would not respond to pain if conditioned to be rewarded with food, and Beecher found that wounded soldiers being sent home were remarkably unfeeling of pain that would otherwise be excruciating.

On the other hand, the inability to cope worsens the consequences of the stress response. Miller raised the example of the myocardial infarction patients in intensive care, where there were five times more deaths when unfamiliar staff made ward rounds. Numerous such examples were presented throughout the conference. Miller's conclusion was that we should concentrate on developing ways of "toughening up" by education and training in dealing with social and emotional problems.

The major portion of the Symposium dealt with recent human studies of coping mechanisms in infancy, adolescence, old age, and in the working environment. Dr. Megan Gunnar (Department of Psychology, Stanford Univ.) discussed the effects of response contingent experiences in early development. There is considerable evidence that how the child approaches life later on depends on the degree of control or helplessness it experiences in early life. Uncontrollable experiences are expected to lead to reduced motivation in adulthood. The mother's responsiveness to the infant provide him with his first coping experiences. The first three months to a year are the most critical, with the second trimester being the most important time for learning response contingency events. The mother's contingent responses affect the infant's behavior in two ways: by providing a source of security, and by developing its confidence and reducing fearfulness in being able to control the environment. The presence and availability of the mother has potent fear-reducing effects particularly after six or seven months of age. Exploration and handling of novel objects and environments facilitate the development of competence in later years as measured by scores on various tests of mental and physical development. The mother's responsiveness to the child's plea also seems to facilitate exploration; however some data indicate that after the child is six months of age, mothers who are too responsive may have infants that are more fearful of uncontrollable events, although they may be less fearful of controllable events. Gunnar pointed out the dearth of objective information in this area, which is further restricted by the limited repertoire of voluntary responses of the human infant, as well as the possible long-lasting harmful effects that may result from some experimental conditions.

The next period of stress in life, early adolescence (10-15), was discussed by Dr. Betty Hamburg (Senior Research Psychiatrist, Laboratory of Developmental Psychology, National Institutes of Health, Bethesda, MD). She proposed that this is a great time of stress because the adolescent is basically a "horrified spectator of events occuring to him." He must cope with a change in the level of difficulty of school work and social pressures which form his "work-world," as well as the uncontrollable changes of undetermined outcome occurring in his body. The adolescent is not happy with his body image. Boys would like to be taller and girls would like to be thinner. It is a time of great concern about the outcome of their growth and development particularly when there are discrepancies from the norm. Fastest growing girls have the lowest self-esteem as do the slower-developing boys. During this age pediatricians report more medical conditions. Approximately 20% of adolescents show an increased amount of worry about their health, and an additional 15-25% show symptoms such as increased blood pressure, neuromuscular and joint problems, ulcers, skin diseases, and juvenile diabetes. Hamburg discussed the statistics that suggest that adolescents who are alcohol abusers are also the ones who are likely to indulge in all the other distress behaviors evidenced in poor school performance, attendance, relationships with parents, depression, use of various drugs. She described preliminary results of success in schools where adolescents were taught coping skills, provided with peer counsellors, and nonparental adults as mentors or sources of information. The criteria used were health indices, school absences and grades, staying in school, and various measures of self-esteem. Hamburg urged the more widespread teaching of coping skills to adolescents for the prevention of health damaging behaviors.

Another aspect of human coping was introduced by Dr. Suzanne Miller (Department of Psychiatry, Univ. of Pennsylvania, School of Medicine, Philadelphia, PA). Will the person who receives information before a surgical procedure, dental procedure, a fatal disease, or hazardous treatment experience less or more stress before, during or after the actual procedure? She described a study of patients going into an aversive gynecological situation (a test for possible cervical cancer). During a 20-minute preparatory slide show it was emphasized that the procedure was basically benign. Various psychophysiological measures were used to measure the response. The conclusion of these investigators was that information was deleterious. In a subsequent study, patients were preselected by questionnaire according to whether they sought/or did not want information about the test that they

were going to undergo. Half of each type were given no information and the other half had information imposed on them. The test, a colpostomy, in general resulted in hand-clenching and increased distress during the exam in the group that had no information, whereas considerably less distress was evidenced by the high information group. MAACL depression scores were increased in the high information group and sustained even after the test, whereas the no information group showed no depression. Being a "monitor" (one seeking information) was emotionally more costly. Such individuals when they came in were more edgy, tended to be more educated, used more pain medication with discomfort, and showed greater muscular tension of the vaginal area as rated by the examining physician. They also took longer to recover. On the other hand, "blunters" (not seeking information) who did not get information did better than those that did. Pulse rate data and self-ratings of tension supported these conclusions. Miller suggested that these findings bear on the issue of informed consent. An individual's right to know should be balanced against his desire to know or ability to handle that information.

Attention was then focused to coping in the work environment. Dr. Marianne Frankenhauser (Department of Psychology, Univ. of Stockholm, Sweden), a pioneer in this field, has done extensive work both in the laboratory and in work conditions relating to job demands, job satisfaction, and health. She has more recently been asking the question: Do physiological measures differentiate between effort with distress, effort without distress, and distress without effort? Her experiments suggest that in the first case both epinephrine (E) and cortisol levels are increased, in the second case only E is increased, and in the third case only cortisol is increased. In conditions involving complex decision making, in which an individual had to find his own pace, she reported that effort and interest and positive feelings were high, as were E and NE (norepinephrine), whereas cortisol excretion was in fact reduced. She also used the Jenkins questionnaire to identify Type A and Type B personalities, who were then placed in a situation where they could select their own work pace. Type A persons subjected themselves to a higher pace, worked faster, made less errors, and showed no difference in physiological measures to Type B individuals, although epidemiological data have shown that high job involvement Type A individuals had less incidence of coronary disease. Her more recent studies with working females in which she measured daytime and evening E excretion show that during the evening household duties and responsibilities, and during the weekend, there is a greater increase in E excretion. However, she pointed out that this measure may not be useful in assessing female work-related responses as it is in males. On the other hand, females who have adopted male work roles, such as engineering students, bus drivers, or lawyers, respond with an increase in E just like males and also show a trend towards increased coronary disease.

Dr. John H. Cullen (The Irish Foundation for Human Development, Dublin, Ireland) has been studying truckdrivers on 4 successive 11-hour days. Performance was measured by quantitating tailgating, braking, and steering wheel handling. He found cortisol levels were decreased on the driving days. Older drivers suppressed more during the day and less at night than younger drivers. He suggested that their higher cortisol levels at night may be due to slightly poorer night vision, a situation that sould make the task harder. Poor performance correlated with high extroversion scores. Cullen measured personality characteristics and extroversion against their level of anxiety in tilt table tests. Extroverts showed high anxiety levels and a large increase in heart rate only during tilt. Introverts showed lower anxiety, but pulse pressure seemed narrower. Neurotics showed higher diastolic pressure and higher heart rate during tilt.

Dr. Holger Ursin (Department of Psychology, Univ. of Bergen, Norway) directed his attention to how disease is produced in response to psychological stress. He proposed that the difference between man and machines is that biological "load" has a training effect and that strain occurs when some kind of balance is surpassed. He described experiments with parachute jumpers during training, measuring numerous physiological parameters. As the fear score decreased, so did cortisol and free fatty acids, whereas testosterone increased. Epinephrine showed an increase every time they jumped, whereas NE de-

creased with successive jumps. He suggested that E is coping-resistant whereas NE is coping-sensitive and may be a better index of somatic risk. Sustained activation is conducive to pathology, but most people subjected to life changes survive most often without damage. Ursin also proposed that personality must be taken into account and that effective coping can reduce pathological damage.

The Symposium was closed by Dr. David Hamburg, President of the Institute of Medicine of the National Academy of Sciences, Washington, DC. He began by reviewing the history of developments coupling psychology and medicine and the resistance over the years of physicians to accept that the central nervous system had anything to do with peripheral disease. He emphasized that this conference formed a cornerstone in the development of awareness of the implications of behavioral aspects of coping to health and disease in the course of living and working.

The proceedings of this excellent Symposium will be published shortly by Plenum Press. The organizers, Drs. Levine and Ursin, are to be heartily congratulated. (J. Vernikos-Danellis, Visiting Scientist, Dept. of Pharmacology, Royal Free Hospital School of Medicine, Univ. of London)

SPACE SCIENCES

THE FRENCH NATIONAL SPACE PROGRAM

Since its inception in 1962, CNES (Centre National d'Etudes Spatiales) has been the national focal point for all French space programs. It is administered by a Board of Directors with a Chairman and a Director General whose responsibility is the day-to-day operation of the organization. A General Secretariat is responsible for budgetary, financial, legal, contractual, personnel, public relations, and other administrative matters. CNES' relations with the European Space Agency (ESA), industrial policies, prospective studies for technology development programs, and other advanced program office activities are handled by a Program and Industrial Department. A Launch Vehicle Department is responsible for all launch vehicle studies, development, and qualifications programs and in particular project management of the French portion of the European Space Agency's Ariane launcher. CNES maintains a launch center at Kourou, French Guiana, which is the launch site for the Ariane and other launch vehicles, both national and international.

By far the largest division of CNES is the Toulouse Space Center. This facility is involved in virtually all areas of space science and technology and provides the in-depth expertise to the various program offices within CNES. The main divisions include Remote Sensing and Data Collection, Space Science, Telecommunications, Project and Technical Research, Mathematics and Computers, and Industrial Projects. The Project and Technical Research Division provides program management for projects that have moved from the conceptual to the development stage, and these project areas consist of satellites, balloons, system and thermal control, and physics and energy.

The three highly significant strictly national programs currently underway at CNES are SPOT (Earth Observation Test System), Telcom I (domestic telecommunications satellite), and a TV broadcast satellite. All three of these projects are extremely ambitious for a country with the gross national product of France and are a good indication of their dedication to the exploitation of space technology. The SPOT program has been under study since 1975 and is now an approved program, with the first launch expected in 1984. As reported in the April 1979 issue of *ESN* under "News and Notes," Telcom I became an approved program in February 1979. The TV broadcast satellite at this writing is still in the study phase, with program approval expected this summer. All of these programs require approval by the President or Prime Minister.

The general aim of the French earth observation program is several fold including: exploring and updating the inventory of nonrenewable and slowly renewable resources such as mineral, hydrological, agricultural, and atmospheric; observation of ecological processes and variations therein as a function of time and location; detection, prediction and control where possible of certain processes relating to oceanography, climatology, soil erosion,

and water pollution; and monitoring dangerous natural phenomena via seismology, volcanology, meteorology, and accidental pollution. With these objectives in mind, it was decided that the SPOT system should be designed around a platform capable of carrying different payloads corresponding to a wide variety of missions.

The SPOT satellite concept requires that a large part of the hardware developed for the first mission be reuseable for later missions. This objective is achieved by (1) developing a bus that contains all the mission-independent subsystems, including attitude and orbit control, power systems, onboard data processing, and telemetry and command; and (2) building payloads that include mission-specific equipment. The first mission will be the investigation of land use and the first payload will consist of two identical "high resolution visible" (HRV) instruments operating in the visible and near IR spectrum. The swath width will be 60 km and the resolution 20 m or 10 m, depending on whether the instrument is operating in the multispectral mode (3 spectral bands) or the panchromatic mode. By rotating a pointable mirror in each instrument it will be possible to adjust their pointing angle over a range of ±26°. This in turn means that it will be possible to obtain stereoscopic pairs of images of a given area and that areas quite distant from the ground track (up to 400 km away) will be accessible. With the satellite in a sun-synchronous orbit at an equatorial altitude of 822 km it can provide systematic coverage of the entire Earth every 26 days, image any given area once every 60 hours, and record stereoscopic pairs of images of a given area. It is this capability that makes SPOT unique, as will be discussed below.

The sun-synchronous orbit assures that the satellite will pass over any given region at the same solar time on each occasion and thus provide images under the same conditions of illumination. In the case of SPOT it is also desirable to maximize the number of occasions when stero pairs of images can be taken at suitable viewing angles and at an interval of one day.

The following orbit parameters were selected for the first SPOT satellite: period of 101 minutes, circular near-polar orbit, inclination of 98.7°, mean altitude of 822 km, repeat cycle of 26 days, and equatorial crossing time of 1030 hrs (descending node). For such an orbit and a maximum instrument pointing angle offset of ±26°, the accessibility to a given zone at 45° latitude (which includes the North Atlantic, Central Europe, the Middle East, Central China, the North Pacific, and the Black Sea among other areas) is as follows: days 1 and 2, 5 and 6, 10 and 11, 15 and 16, 20 and 21, and 25 and 26. If four satellites are used, these areas could be covered every day! This capability could be invaluable for observing ship movements and land traffic patterns as well as other phenomena mentioned earlier. Various latitudes could be observed on a daily basis by changing the orbital parameters of the satellite and instrument offset angle.

The multimission platform or bus that is expected to evolve from the first SPOT mission is to be capable of supporting a maximum payload mass of 800 km in a circular sun-synchronous orbit at altitudes between 570 and 1200 km for a lifetime of over two years. The solar array power at end of life is to have a maximum of 1.2 kW. The possibility of launching two SPOT satellites or a SPOT and another type satellite simultaneously with an Ariane is being seriously considered in the current development stage, i.e., the total mass of the SPOT is about half the sun-synchronous launch capability of the Ariane as are other satellites being developed by ESA and CNES.

The prime contractor for SPOT is the French firm MATRA, and the development costs in 1977 figures were anticipated at 700 million French francs (FrF), which includes two satellites and one launch. Additional production models are expected to cost 60-80 million FrF per model, depending on the payload. This is $15-20 million a copy, which may be a bargain when the potential uses of a SPOT-type satellite are imagined.

The Telcom I domestic telecommunications satellite will provide mainland coverage of France (including Corsica) in the 11-14 GHz bands and overseas coverage of the French possessions of La Réunion (near Madagascar), St. Pierre and Miquelon (off the south coast of Newfoundland), the Antilles Islands of Guadeloupe and Martinique, and Guiana in the 4-6 GHz bands. The mainland coverage will primarily provide digital data transmission for industry via computer links, while the overseas coverage

will provide primarily television and telephone transmissions. The French Post and Telecommunications is the customer for the system and will provide specifications for the satellites as well as serving as contracting agent for the earth terminals. CNES will act as the contracting agent for the space segment. The satellite will be of the ECS (ESA European Communication Satellite) class utilizing as much technology transfer as possible. ECS is a three-axis stabilized satellite with a design life in geosynchronous orbit of seven years. It consists of a service module or bus providing all the basic service functions such as prime power, stabilization orbit and attitude control, and a payload module. The mass at launch of the entire spacecraft is 830 kg and the on-orbit mass at beginning-of-life (BOL) is 480 kg. The payload mass is approximately 90 kg. The BOL power at solstice is 900 W and the operating voltage is 50 V. It has a pointing accuracy of 0.2° on antenna boresight and 0.35° yaw. The Telcom I will have two payloads—one serving the 4-6 GHz bands and the other the 11-14 GHz bands. Both will incorporate six fully redundant transponders. The global beam, which will provide overseas coverage, will operate into 15-m antenna earth terminals while spot beams will provide the coverage at 11-14 GHz working into 3-m antenna earth terminals. Design specifications are provided for the communications' packages and performance specifications for the spacecraft. The system will operate with one operational satellite over the Atlantic at approximately Lat 10° W and one on-orbit spare.

The television broadcast satellite would be in the ESA H-Sat category (*ESN* 32-9:316) utilizing the full launch capability of the Ariane. The French are discussing sharing the program with the Germans for both practical and economical reasons, the former being the fact that the satellite capacity will be in excess of initial French requirements. Current plans would be to place the satellite in geosynchronous orbit at approximately Lat 19° W with one 2.5° × 1° beam containing two 27-MHz channels providing coverage of France and one 1.4° × 0.8° beam containing three 27-MHz channels covering Germany. The uplink frequency will be 11.7 GHz and the downlink 12.5 GHz. Initial plans are to use 0.9-m "rooftop" antenna earth terminals, since satellite output power is limited by the WARC (World Administrative Radio Conference) to 64 dBW. Research is currently underway to develop smaller antenna earth terminals.

The TV satellite will be three-axis stabilized, utilizing a magnetic bearing momentum wheel with redundant bearing electronics. Conventional chemical thrusters will be used for attitude control and station keeping. The prime power system will use conventional solar cells capable of providing an end of life power of 4.0 kW. No batteries will be provided for eclipses since these periods will generally occur in the early hours of the morning (0100-0200), and the weight penalty was not considered worth paying, as the satellite will have a BOL mass of 1000 kg initially and grow to 1150 kg as the capability of the Ariane is increased. The communications payload is still very much under study with research being carried out to develop a higher power traveling wave tube amplifier (TWTA) and multi-feed shaped beams. Two TWTAs of 220 W and 50% efficiency are to be used, in parallel for each channel, to provide power amplification if a higher power 450-W TWTA is not available. A third TWTA would be used for each channel, to provide a one for two redundancy.

The systems studies for the TV satellite are completed and some subsystems are under development. Once the decision is taken to go ahead with the program it is expected to take 44-48 months until the first launch. This is now anticipated to be in mid-1983. (Robert W. Rostron)

NEWS & NOTES

ARTIFICIAL EAR

Encouraging initial results with a new hearing aid for the deaf have been obtained by Dr. Erwin S. Hochmair and Ingeborg J. Hochmair-Desoyer, two investigators at the Vienna Technical University. The work is the combined effort of these researchers from the Institute of General Electro-Technology (headed by Prof. F. Paschke) and the Institute of Physical Electronics (headed by Prof. J. Pötzl), and of Prof. K. Burian, of the II ENT Clinic at Vienna University.

A conventional hearing aid is a booster device that compensates for loss in sensitivity by amplifying the sound up to 10,000 times. Such a device will not help people whose sensory cells, instrumental in generating nerve impulses have been destroyed. For such individuals, an estimated 150,000 of whom are in Europe, only direct stimulation of the nerves will provide a "hearing" sensation.

Earlier attempts to excite the cochlea, the spiral tube of the inner ear that contains the more than 20,000 auditory nerve endings, directly with electrical signals from a microphone failed to produce intelligible hearing. It was concluded that any artificial electrical stimulation would have to reproduce the complex spike patterns found in a normal ear. The Hochmair device is an implanted microcircuit that aims toward accomplishing this task.

Although the mechanism of pitch discrimination is not yet completely understood, it is generally accepted that one contributing factor to the sensation of pitch is the location of the nerve fiber. This has suggested that pitch discrimination could be obtained by electrically contacting only a few regions of the cochlea, instead of all of the nerve fibers. In the Hochmair device, eight narrow regions of the cochlea have been contacted electrically by the microcircuit. So far, five patients have had such hermetically sealed microcircuits implanted in the scala tympani portion of the cochlea.

An external, battery-operated transmitter completes the system. Sounds picked up by a microphone enter a processor, where they are transformed into the pulse patterns capable of stimulating the nerves. The transmitter output is fed across the skin to the implanted circuit via coupled coils, which are also used to power the implanted microcircuit from the outside. This avoids wiring through the skin and thus removes a possible source of infection.

Results to date show that patients are able to experience "pleasant" hearing sensations of varying pitch and volume. So far, no speech has been transmitted in this manner. However, the patients have been able to get an idea of the rhythm, modulation, and volume of what was being said. In particular, with this device the deaf quickly receive an indispensable awareness of the various sounds and noises which surround us.

The implant has thus become a valuable tool for further research into electrical stimulation of the auditory nerve. It is hoped that systems of this type will soon lead to techniques that will allow the deaf to understand speech aurally.

At this time, the Hochmairs are in the United States, where they are spending time at the Institute for Electronics in Medicine, Stanford University. (Irving Kaufman)

RESEARCH GRANTS CUT IN BRITAIN

Of much concern to the scientific community in Britain is the effect that the new Government's Budget cuts (announced 13 June) will have on vital research. Funds to all of the Research Councils have been reduced the total of £5,100,000, this sum being allocated as follows:

Science Research Council	£2.6 M
Medical Research Coun.	0.5 M
Social Science Res. Coun.	1.5 M
Natural Environment Res. Coun.	0.4 M
Agriculture Res. Coun.	0.1 M

In addition a further £8.0 M was cut from university recurrent grants.

As a result of the cuts, many senior scientists and medical researchers are expected to lose their positions. According to *The Daily Telegraph* (21 June 1979) "...there are fears that many research staff employed on short-term contracts—there are some 9,000 of them in all—might find themselves out of jobs."

To quote Mr. John Akker, Deputy General Secretary of the Association of University Teachers, "These reductions will inevitably increase unemployment among scientists at a time when the country most needs their skills."

PERSONAL

THE QUEEN'S 1979 BIRTHDAY HONOURS

In this summer's Honours three scientists were named Knight Bachelor (KB): Professor Geoffrey Allen, Chairman, Science Research Council: Basil John Mason, Director-General of the Meteorological Office; and Prof. David Chilton Phillips, Biological Secretary

of the Royal Society. In the Civil List, several were named Commander Order of the British Empire (CBE): S.C.C. Bate, lately, Deputy Chief Scientific Officer, Dept. of Environment; R.E.D. Bishop, Professor of Mechanical Engineering, University College, London; A.J. Lee, Director of Fisheries Research, Ministry of Agriculture; and R.E. Steiner, Professor of Diagnostic Radiology, Royal Postgraduate Medical School, London.

Imperial College of Science and Technology, University of London, has announced the retirement of the following professors: Professor W.R.S. Garton, Professor of Spectroscopy in the Blackett Laboratory. He has been appointed to a Senior Research Fellowship in the Department of Physics on his retirement. Professor John Stuart Webb, who retired from the Chair of Applied Geochemistry at the end of this academic year, has also been appointed a Senior Research Fellow.

Dr. D.W. Pashley, FRS, Research Director of Tube Investments and Director of Tube Investments Research Laboratories, has been appointed to the Chair of Materials in the Department of Metallurgy and Materials Science at Imperial College from 1 September.

ONRL REPORTS

R-3-79 DEVELOPMENTS IN ACOUSTIC TRANSDUCTION IN WESTERN EUROPE by R.J. Bobber

A survey of applied research and development in underwater acoustic transduction in Western Europe reveals a widespread interest in piezopolymers and some potential in fiber optic acoustic sensors. Little else in innovative transductions concepts was found. An electrical charge insertion theory and the production of thick PVF, films may each have significant effects on piezopolymer hydrophone development.

C-2-79 NATO SYMPOSIUM ON COPING AND HEALTH, BELLAGIO by J. Vernikos-Danellis

Highlights are discussed of papers presented at the NATO symposium on Coping and Health, held 26-30 March 1979 at the Bellagio Study and Conference Center of the Rockefeller Foundation. This Symposium was a scholarly summary by 20 leading world authorities in the field of Stress and Coping techniques. Experimental data from animals and experimental and clinical data from humans formed the basis of the discussions.

C-3-79 1979 SPRING REVIEW COURSE: PHASE TRANSFORMATION, 4-7 APRIL 1979, YORK, UK by J. Perkins

The proceedings at the conference are reviewed, including papers on all classes of phase transformation, on new methods of research, and on examples of applications. Precipitation, martensitic transformations, order-disorder reactions and other types of phase transformation are included. Other topics include morphological instability in microstructures, phase transformations in ceramics, and the effect of industrial processing on transformations.